

MAY 26 1924

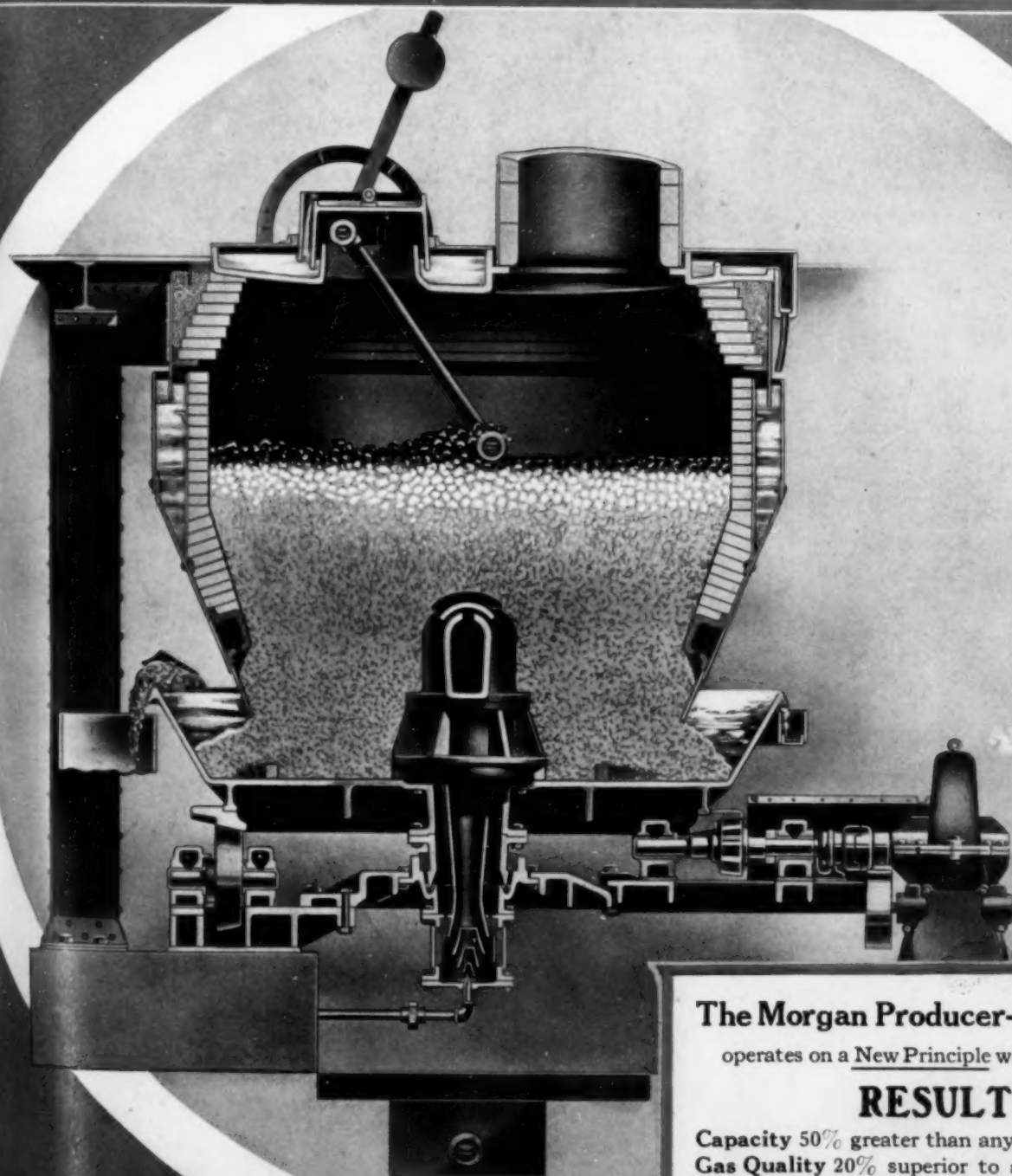
# Metallurgical & Chemical Engineering

Volume XIII.

Number 7

July, 1915

McGraw Publishing Co., Inc.



## The Morgan Producer-Gas Machine

operates on a New Principle with the following

### RESULTS

Capacity 50% greater than any other type.

Gas Quality 20% superior to any known record.

Labor eliminated. Coal fed mechanically from bin.

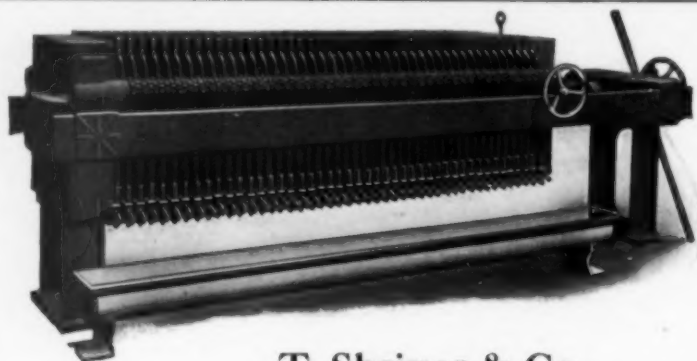
No poking.

Cost per unit of capacity greatly reduced.

New catalogue.

**Morgan Construction Company**

Worcester, Mass.



**T. Shriver & Co.**  
808 Hamilton St., Harrison, N. J.

### Less Cost—More Filtering With Shriver Filter Presses

Longer filter cloth life and the lessening of leakage by superior mechanical construction co-operate with a saving in labor and time to make the Shriver preeminently the economical filter for all purposes.

Its wide use in the important filtering work of this country guarantees the character of its performance under all conditions.

SEND FOR THE ILLUSTRATED CATALOG

2631

## INTRODUCING— TWO NEW ALLOYS

### Nickel Copper Alloy of 50% Nickel and 50% Copper

In response to a number of requests for an alloy of Nickel and Copper for use in the manufacture of german silver castings and bronzes of high physical properties, we are now supplying an alloy of Nickel and Copper. The special advantage of this 50/50 alloy is that it dissolves at a very low temperature—very much lower than metallic nickel, so that when this alloy is used, it is not necessary to raise the temperature of the pot above normal. Nickel is also used to prevent segregation of lead in a plastic lead or bearing alloy. In all so-called red metal alloys where nickel is introduced to promote fineness of grain and increase of tensile strength, such a combination of Nickel and Copper as we now supply should be found of great economical advantage. There have been increased calls for this alloy, and reports from its use have been especially encouraging. Prices will be quoted on application.

### Manganese Aluminum Alloy of 25% Manganese and 75% Aluminum

We are now producing an alloy of 25% Manganese and 75% Aluminum made from our 98% pure carbon free Manganese. The resulting alloy is, therefore, technically free from iron and carbon, both of which are considered extremely detrimental in aluminum work. This alloy dissolves at an exceedingly low temperature and its effect on aluminum castings would be to reduce shrinkage, close the grain and promote density. We have just had a very encouraging report from one of the largest government shops regarding the use of this alloy, in which they state that experiments are being conducted and the results obtained indicate that a considerable increase in strength without loss in ductility can be obtained by the judicious use of this alloy. In the past, many aluminum casting companies used the ordinary 80% Ferro Manganese containing about 5% to 8% of carbon, but the 25/75 Manganese Aluminum which we are now supplying, being technically free from iron and carbon, naturally has many important advantages over any other Manganese Aluminum alloys that have been produced.

In addition to the above, the following alloys will be of interest to manufacturers of Brass, Bronze, Aluminum and Nickel castings:

- 30% Manganese Copper, Grade "A," technically free from iron and carbon.
- 30% Manganese Copper, Grade "B" (2% or 3% iron).
- Manganese Titanium (about 35% Ti.).
- 98% Pure Carbonfree Manganese.

For iron and steel foundries we can recommend the following metals and alloys, which are produced free from carbon and of exceptional purity and uniformity by the Thermit Process.

- 98% Pure Chromium.
- 60% Ferro Chromium.
- 97% Pure Cobalt.
- 25% Ferro Titanium.

80% Ferro Molybdenum.

For further particulars regarding our metals and alloys, write for our pamphlet No. 2041, and state particularly the metals or alloys on which special information is desired.

## GOLDSCHMIDT THERMIT COMPANY

WILLIAM C. CUNTZ, General Manager  
90 WEST STREET, NEW YORK

329-333 Folsom St., San Francisco

103 Richmond St. W., Toronto, Ont.

7300 South Chicago Ave., Chicago



# Metallurgical and Chemical Engineering

A Consolidation of  
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

Vol. XIII

NEW YORK, JULY, 1915

No. 7

PUBLISHED MONTHLY BY THE  
**McGRAW PUBLISHING COMPANY, INC.**

JAMES H. McGRAW, President.  
A. E. CLIFFORD, Secretary. JOHN T. DeMOTT, Treasurer.

239 West 39th Street, New York.

TELEPHONE, 4700 BRYANT. CABLE ADDRESS, METCHAM, NEW YORK.  
ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Colo.  
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.  
CHICAGO OFFICE.....Old Colony Building  
CLEVELAND OFFICE.....Leader News Building  
PHILADELPHIA OFFICE.....Real Estate Trust Building  
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, Ph.D., Editor.  
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

Yearly subscription price for United States, Mexico and  
United States dependencies, \$2.00; all other countries, \$2.50.  
(European exchange, 10 shillings, 10 marks, 12.50 francs.)

Copyright, 1915, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York,  
N. Y., under the Act of Congress, March 3, 1879.

## Contents for July, 1915

EDITORIAL:	
Patent Suit Procedure.....	405
Steel Shape and Rod Production .....	405
Effect of Zinc Prices on Cyanidation.....	406
The Field for Engineers .....	406
Steel Corporation Allowed to Live.....	407
READERS' VIEWS AND COMMENTS:	
The Neutrality of Science. By Joseph W. Richards.....	408
Flotation Results. By Rudolf Gahl.....	408
An Interesting Application of Colloidal Chemistry. By Daniel T. Pierce .....	408
Flotation Suit .....	409
Bakelite Suit Decision .....	411
Court of Appeals Decision in Nickel-Chromium Resistor Suit.....	414
The Western Metallurgical Field.....	415
The Iron and Steel Market.....	417
The Western Trip and the Los Angeles and San Francisco Meetings of the American Institute of Chemical Engineers.....	418
The Western Trip of the American Chemical Society.....	419
Special Trains of Civil, Mining, Mechanical and Electrical Engineers to International Engineering Congress .....	419
The Western Trip of the American Electrochemical Society.....	419
The Corrosion Problem Before the American Iron and Steel Institute .....	420
Cyanidation of Low-Grade Sulphide Ores in Colorado—I. By H. C. Parmelee .....	421
Furnace Curves. By R. J. Weitlaner.....	425
Blast-Furnace Plant Auxiliaries and General Arrangement. By J. E. Johnson, Jr.....	429
The Relative Migration Velocity of the Ions in Complex Elec- trolytes. By A. Mutscheller.....	439
Good Advice to Consulting Metallurgists.....	442
METALLURGICAL AND CHEMICAL ENGINEERING IN GREAT BRITAIN SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERA- TURE .....	446
RECENT CHEMICAL AND METALLURGICAL PATENTS.....	449
Welding Up Scrap Nickel Anodes.....	453
The Course in High Temperature Measurements at Purdue University .....	454
A New Diaphragm Pump .....	455
British Producer Gas and Ammonia Recovery Plant.....	456
Exhibits at the San Francisco Exposition.....	458
Air Compressor .....	460
American-Made Porcelain Ware for Chemical Laboratories.....	461
The Non-Ferrous Metal Market.....	461
Personal .....	461
Obituary.....	462
Newspaper Chemistry.....	463
National Exposition of Chemical Industries.....	463
DIGEST OF ELECTROCHEMICAL U. S. PATENTS.....	463
BOOK REVIEWS .....	464

## Patent Suit Procedure

This issue contains an unusual amount of news on important patent suits: a sketch of the present status of the flotation suit, an account of the District Court decision in the bakelite suit, and an account of the Court of Appeals decision in the nickel-chromium resistor suit. The flotation suit is probably the most momentous patent suit now awaiting decision, as flotation will ultimately become one of the greatest agents in the conservation of our mineral resources—but not until the patent situation is settled. To accelerate the slow pace of patent law procedure is one of the greatest industrial problems of the day.

In this respect the bakelite suit is of interest, as it was one of the very first suits tried under the new open-court system. The final argument was made on Feb. 20 and 21, 1914. The decision was rendered on June 12, 1915. While the interval seems long, it is safe to assume that under the old rules the trial would still be going on for years to come.

Nevertheless our methods of court procedure could be made considerably less complicated. Reforms could be introduced whereby the presiding judge would not be compelled to study in every case every detail of highly specialized scientific or technical testimony, which requires not only intelligence, but long technical training. Matters would be still further simplified if the question of validity or non-validity of a patent could be referred to a technical court, where simple, relatively inexpensive, and direct proceedings could be instituted, similar to the nullification proceedings in Germany. The decision of such a technical court would be a direct guide for the judge so as to decide on the question of infringement. Some reform along such lines would be eminently desirable.

## Steel Shape and Rod Production

Statistics of production of shapes, rods and nails in the United States in 1914 have just been presented by the Bureau of Statistics of the American Iron and Steel Association.

Measured by the basic material, pig iron, 1914 was a decidedly poor year, for the pig iron production, 23,332,244 gross tons, was almost 25 per cent less than the record output made in the preceding year. The production of structural shapes suffered slightly more than the average, as the 1914 production, 2,031,124 gross tons, showed a decrease of 32 per cent from 1913. That was quite natural, for as the total demand for iron and steel rises and falls from year to year, the fluctuations are made more largely by the materials which enter into more or less permanent structures, or are involved in



the investment of capital, while the articles of everyday consumption show much smaller fluctuations. The production of structural shapes has shown more conspicuous illustrations of this fact than the illustration afforded by the 1914 statistics, for in 1908 the production of shapes was less than half the production in 1906, whereas the production of pig iron suffered a decrease of only a trifle more than one-third.

For an article representing common everyday consumption, no better commodity could be selected than wire rods, and it is a happy chance that brought the rod statistics for 1914 to light at the same time as the shape statistics. We find that the production of rods in 1914, 2,431,714 gross tons, was only 33,000 tons less than the production in 1913, and we also find, interestingly enough, that 1913 was not the banner year for rods, 1912 retaining that honor with 2,653,553 tons. There have indeed, been nothing like violent fluctuations in the production of rods since the early days of the industry, when the production was increasing rapidly because the wire nail was supplanting the cut nail. The production of nails, cut and wire, has been quite steady; of the past 11 years the best was 1912, with 15,638,115 kegs, and the poorest year 1908, with 11,619,154 kegs. No other important steel commodity has shown such slight variation.

A rather interesting statistical event occurred in 1914, the production of rods for the first time exceeding the production of rails. This was an event long predicted. In fact, it was predicted altogether too soon, at a time when the production of rods was experiencing a temporarily rapid growth on account of the supplanting of the wire nail by the cut nail, already referred to. There is not the least reason to suppose that rods have permanently passed rails in tonnage. The passing in 1914 was due simply to the fact that in an "off" year rail production suffered severely while rod production suffered scarcely at all. In 1914 the rod production was 2,431,714 tons and the rail production 1,945,095 tons, but in 1906, eight years earlier, the rail production was 3,977,887 tons, and it will probably be easier, in future years, for the rail tonnage to regain that height than for the rod production to attain it. Given still more time, however, the rod tonnage may permanently pass the rail tonnage.

#### Effect of Zinc Prices on Cyanidation

With spelter at 25 cents per pound, zinc sheets at 30, and zinc dust at 28 to 32, a decided dislocation has resulted in the cost of precipitating cyanide solutions. The sudden prosperity of the producer of zinc is reacting unfavorably on the producer of gold and silver by the cyanide process, raising the cost of precipitation to a point where substitute methods are being considered. In spite of technical improvements in precipitating practice, the irreducible minimum cost has assumed abnormal proportions. Six months ago spelter was quoted at 5.5 to 6 cents per pound, zinc sheets at 8.5 to 9, and zinc dust at 10. Current prices are three to five times as great.

In the reports of those companies that give annually

a detailed cost of milling operations, we find the following data on precipitation: At Goldfield Consolidated, using zinc dust, the cost of precipitation in 1914 was 6.2 cents per ton of ore milled, out of a total milling cost of \$1.606. At the Hollinger, where zinc dust also is used, the precipitation cost of 6.3 cents per ton of ore milled, out of a total cost of \$1.237. For similar precipitation at the Commonwealth, in Arizona, the cost was 11.6 cents, out of a total of \$1.879. These precipitation costs range from 3.86 per cent to 6.17 per cent of the total cost of milling, ranking with the costs of crushing and conveying, settling, filtering and concentration, where the last is practised. Excepting stamping, tube-milling, and agitation, which show the highest itemized costs, precipitation is quite as important an item as any other in the total cost of cyaniding.

It is not surprising, therefore, that managers are giving careful thought to the present conditions. Precipitation by aluminium dust for Western cyanide mills has long since been investigated by some companies, but as far as we are aware none has adopted it. Other changes have been contemplated in general methods of operation. In one instance, where cyanidation had superseded amalgamation and concentration, the advisability of temporarily reverting the former practice was investigated, but found unprofitable even at the present high cost of zinc for precipitation. While this is a strong endorsement for cyanidation, the company's action shows the influence of current conditions.

One of the most striking effects of the high price of zinc is a renewed interest in electrolytic precipitation of cyanide solutions. Experiments of this sort are under way at one mill, and the early results appear encouraging. The work is in competent hands and the outcome will be awaited with interest. Regardless of the ultimate effects of the present zinc market on cyanide metallurgy, all the investigations under way indicate a healthy condition in the management of our metallurgical concerns.

#### The Field for Engineers

With the recurrence of the annual graduating season, new accessions have been made to the ranks of the engineering professions, and one hears again the old familiar question, "What becomes of all the engineers?" The same query may well be put regarding lawyers, physicians and others who have pursued a course of special training. The inference is that all of these specialists cannot find lucrative employment in their chosen lines; that the professions are overcrowded and opportunity for success is consequently limited.

It is a fact that there is a growing tendency for engineering graduates to assume vocations apparently unrelated to the particular branch of engineering in which they were graduated. This, however, is not an argument against the pursuit of an engineering education, for the fundamental qualities of such training are adaptable to success in a wide variety of commercial operations. The engineering graduate, of whatever brand, should be well fitted to observe keenly, analyze with precision, draw correct conclusions, discriminate



between essentials and non-essentials, and attain his ends by the most direct and economic route. Such qualities as these are appropriate in the administration of any branch of business, and should enable their possessor to rise rapidly and prove himself invaluable. It makes little difference what particular label is placed on the engineering graduate. If he is well grounded in the fundamental qualities of an engineer, he is fitted to become a most useful member of society.

There is ample evidence that the ramifications of engineering are extending into many branches of business. National, state and municipal affairs require engineering direction. Imagine the beneficent results flowing from a legislature composed of fewer lawyers and more engineers; not that lawyers are unnecessary, but that they deal unintelligently with matters foreign to their knowledge. Salesmanship of the highest type is open to engineers in fields where the "drummer" is inefficient. The field of insurance also is open, with the adoption of workmen's compensation laws in the mining states. Recently we were asked to recommend to an insurance company an engineer capable of inspecting mining and milling properties for purposes of setting the premium rates for liability insurance. Such an engineer might never mine or mill a pound of ore, but he could develop a field for special talents. The uses of an engineering training are not confined to actual field work. Society has many benefits to gain from a wider spread of such training among young men.

### Steel Corporation Allowed to Live

Practically everybody but the plaintiff appears to have been pleased by the decision handed down June 3 in the United States Steel Corporation dissolution suit in the United States District Court of New Jersey. As a matter of fact, it would not be necessary to await expressions of opinion after the decision, for the witnesses the corporation brought to the hearings represented the majority of its competitors and customers, and there was favorable testimony also as to the corporation's treatment of its employees. Naturally the interests thus arrayed on the corporation's side are pleased with the verdict.

Comment that has been passed upon the case since the decision was rendered has run so largely to the expression of gratification upon the result that some interesting long-range observations have not been emphasized as they should be, if we as thinking individuals are to profit by the experience. How strange it would seem to the conventional inhabitant of Mars if he were given but the skeleton, that the Sherman law was passed in 1890, that combinations in restraint of trade were formed in 1898, 1899 and 1900, that these combinations were themselves united in 1901, that they entered into illegal arrangements with outside interests at various times as late as 1908, that in 1911 the government brought suit under the Sherman law and that in 1915 the corporation was given a clean bill of health as a result of that prosecution! The Martian would probably at once inquire why the suit was not brought earlier, when a conviction, apparently, could easily have

been secured, and if nobody desired a conviction at that time, why the law had ever been enacted.

Reply might be made that the Knight Sugar Trust decision of 1904 had apparently interpreted the law so that it could not be made to apply to the Steel Corporation or the prior consolidations, while subsequent decisions suggested that possibly the Steel Corporation might be found guilty, thus encouraging the Government eventually to bring the suit. At the time of the Knight decision, however, the Sherman law was already fourteen years old, and it was only seven years older when the steel suit was brought.

One can scarcely avoid the conclusion that public thought has had much to do with molding the course of events. The Sherman law was not taken very seriously in its early years. It put some inconvenient restraints of secrecy upon those who entered into trade restraint combinations, but enough was known to have formed the basis for many prosecutions if the people had been ready for them. Later there was a great awakening on the part of the people as to their commercial rights, but at first their desires were inadequately expressed for they had not the knowledge and experience. The revolution in public thought was one thing and the clamor of the "muckrakers," as we now know, was another. While condemning the muckrakers, the leaders in industry and finance recognized the rightness of the revolution in public thought, and reforms were instituted. Judge Gary, himself, the chairman of the Steel Corporation, has frequently and strongly expressed the view that business needed to be reformed and that it had reformed. The decision in the steel suit, including both the opinion rendered by Judge Ruffington and the separate opinion by Judge Woolley, reaching the same conclusion but by a separate process of reasoning, condemns much in the Steel Corporation that has passed into history, while entirely vindicating the corporation as it stands to-day, or as it stood on the day upon which the suit was brought.

Thus we have a gradual changing and molding of public opinion whereby the rights of the public are declared, and a changing in the conduct of business whereby those rights are recognized.

What is particularly gratifying is that sufficient time chanced to be allowed for "big business" to be judged by its performance and not by academic theory. It was an economical necessity that "big business" should come. Given time it would show its right to exist by benefiting the public. Fortunately that time was furnished. Instead of regarding the corporation as a menace because it was big, the court observes in substance that the bigness was desirable for economic reasons, and gives the readily comprehended dictum that it is not the size of the corporation, but the importance of the power that was not acquired, that should govern the decision in the case. The extent of the power that was not acquired was shown clearly by the testimony, that nine important competitors of the corporation had grown in capacity at much greater percentage rates than had the corporation, and that the corporation's proportion of the country's total output had steadily diminished.

## Readers' Views and Comments

### The Neutrality of Science

*To the Editor of Metallurgical & Chemical Engineering*

SIR:—Many, many lamentable things have happened in the "World War" which is desolating Europe, but one of the most unexpected, to scientific men, has been the regrettable action taken by the British Iron and Steel Institute, in London, on May 14th last. At the meeting on that date the Council of the Institute put the following resolution before the members present, which was "carried unanimously":

"That the names of all alien enemies be struck off the list of members of the institute, and that steps be taken to amend the by-laws so that they provide for the future that, in the event of war existing between this and other countries, citizens or subjects of which are honorary members or members of this Institute, such honorary members or members shall *ipso facto* cease their membership."

Being a born Englishman, the undersigned may not lightly be charged with anti-British sympathies; being also a member of the Iron and Steel Institute, he may be granted the right to express publicly his disapproval of the above action. But speaking from the broader standpoint of a believer in the international character of science and the salutary saneness of the scientific spirit, he wishes to voice his deep regret that such a dignified Institute, such an honored and honorable society, should stain its annals by an act of such lamentable folly.

In this pandemonium of strife, collapsing of the safeguards of civilization, reversion towards primitive barbarism, where shall the seeds of future peace and harmony be found if the fraternity of scientific brotherhood and mutuality is also swept into the abyss? There must and there will come an "after the war," when reconstruction of the desolated earth will be the common task. Then conquerors and conquered must and will work towards a common end, and then will come the need of mutual co-operation and re-established goodwill. And where could a better starting point be found than in the fraternal bonds of international scientific co-operation?

Alas, our ideals are being shattered and our hopes falter when we contemplate the short-sighted action of the venerable Iron and Steel Institute. All honor to Professor Turner, who raised a protesting voice in the discussion, telling them that they would live to sorely regret their hasty action.

The writer believes that he voices the sentiments of the majority of members of the Iron and Steel Institute in America, in deploring this ill-advised, short-sighted, and altogether regrettable action. He believes, further, that this would be the nearly unanimous view of American scientists in general. The escutcheon has been blotched. Members of the Iron and Steel Institute in Great Britain repent your haste, rescind the action, and wipe out the blot.

Lehigh University.  
June 15, 1915.

JOSEPH W. RICHARDS.

### Flotation Results

*To the Editor of Metallurgical & Chemical Engineering*

SIR:—May I call your attention to an error in the editorial on "flotation as a conservation measure" in your June issue?

You say that the recovery from sulphide ore in the Inspiration Company's experimental mill last February was 90.3 per cent, or from 20 per cent to 25 per cent

greater than at five other porphyry copper mines. This is evidently a misunderstanding of a statement in Mr. Mills' yearly report, which was to the effect that 90.3 per cent of the copper occurring in sulphide form was being recovered. It is known, of course, that all these porphyry ores are partly oxidized and that to get a fair comparison between the work done at different reduction plants it is necessary to discriminate between recovery made on the sulphide copper contents and on the oxide copper contents, as Mr. Mills has done in the report in question.

I think it will be found that the other porphyry copper mines also make a fairly good sulphide recovery, although there is no doubt that the flotation process will assist materially in raising it. But improvements of from 20 to 25 per cent with which you credit us are out of the question, as long as the oxide recovery is not raised materially. The prospects are bright that this will be done in the near future.

Inspiration Consolidated Copper Co.,  
Miami, Arizona.

RUDOLF GAHL.

### An Interesting Application of Colloidal Chemistry

*To the Editor of Metallurgical & Chemical Engineering*

SIR:—It is fairly evident from the progress already made that colloidal chemistry will within a short time place many industries under heavy obligations to this rapidly advancing branch of science. Some suggestion as to this is contained in the chapters on the applications of colloidal chemistry in tanning, dyeing, soil improvement, sewage purification and biology in a volume on this subject by W. W. Taylor of the University of Edinburgh ("Chemistry of Colloids and Some Technical Applications"; Longmans, Green & Co., New York, 1915). A striking example of the aid this department of chemistry may afford in explaining hitherto unaccounted for industrial results, and in providing a line along which rational improvement may be sought, is found in the investigations of Clifford Richardson in connection with the colloidal nature of Trinidad asphalt and the results of these investigations as applied to the asphalt paving industry.

Mr. Richardson's work in this connection is also a good example of the value of the chemist's services. A lecture on colloids delivered by Wolfgang Ostwald, the great authority on this subject, at the laboratory of the College of the City of New York, early in 1914, supplied the first suggestion that colloidal chemistry could aid the asphalt industry, although Dr. Ostwald made no special reference to bitumens in his review of the past ten years' study of colloids. In a memorandum dictated the day after the lecture, however, Mr. Richardson said: "It is evident that a portion of the clay in Trinidad asphalt is in this condition, and this throws a great light on the character of this substance and explains why it differs in some respects from all other bitumens with which we are acquainted. It has very probably acted as a catalyzer in producing a peculiar form of bitumen, and by its presence in the bitumen, as used, confers upon it properties which are unique. The field this affords for investigation is interesting and worthy of study."

Since the date of this memorandum Mr. Richardson has spent a year of study and laboratory investigation with results that should mean more to the asphalt paving industry than any discovery that has been made



in many years. The conclusions from this study clear up many conceptions that have heretofore been held merely as theories, or which have been applied in a rather haphazard manner; they point the way toward rational rather than empirical methods in the preparation of paving formulas.

Every since Mr. Richardson's standard work, "The Modern Asphalt Pavement," appeared in 1905, the fact has been generally realized that the perfection of a sheet asphalt paving mixture will depend very largely on the surface area of the particles composing the mineral aggregate of sand or filler entering into the mixture. In the minds of most of those—even the experts—who are engaged in the industry, the grading and the fineness of the mineral aggregate is supposed to have little importance outside of the extent to which a fine grading will "carry" the bitumen. Any paving man knows that a fine aggregate will carry more bitumen than a coarse aggregate, but that is about as far as he has gone.

Mr. Richardson's investigations have now shown that the extent of surface area presented in any mineral aggregate, especially if it embodies colloidal material, has a great importance in addition to the carrying of the bitumen.

A pound of coarse sand such as might be used in a paving mixture is found to contain 129,030,065 particles with 44,378 square feet of surface. A finer sand of the type used in some of the most successful pavements laid in New York in the 90's contains 232,075,324 particles to the pound, these particles having 60,503 square feet of surface. Going a step further in these investigations it is found that the number of square feet of surface in a pound of dust or filler used in a paving mixture is 527,821. Dust or filler of the latter characteristics, that is, of from 0.08 to 0.0025 mm., is estimated to run 192,715,000,000 particles to the pound, and has been considered the ultimate of fineness in paving mixtures.

These figures are given for the purpose of permitting a comparison between ordinary conceptions as to how fine the aggregate of a paving mixture may be and the degrees of fineness we encounter in the field of colloids. For the purpose of comparison with the above it is pointed out by Mr. Richardson that if the amount of material represented by a cube having a dimension of 1 cm. is reduced to the coarsest colloidal size (ten-thousandths of a millimeter in diameter) the surface area of the material in the 1 cm. cube would be increased 100,000 times.

It had already been demonstrated that a large surface area was a necessary feature of the mineral aggregate of an ideal paving mixture; hence the addition of the finest dust that could be obtained. Service tests had shown that pavements such as those laid on Fifth Avenue, New York, the Victoria Embankment in London, and Vermont Avenue, Washington, D. C.—the latter being in use for 35 years—containing the largest amount of the finest obtainable material, are the most durable. The reasons for this, however, were not entirely clear, except in the particular already pointed out; namely, that the finer the aggregate the more bitumen it would carry without excess.

All of these pavements were constructed with asphalt containing colloidal clay, and it is now appreciated as a result of Mr. Richardson's studies, why the results in the cases cited were obtained. The power of selective adsorption possessed by colloids is shown to be of prime importance in the sheet asphalt paving industry, because the surface of the mineral aggregate adsorbs selectively and holds with great power the bitumen which is used as the binding material or cement. In Trinidad asphalt there is a considerable amount of

mineral matter present in a dispersed solid colloid form which shows great capacity for adsorption, selecting the denser portions of the bitumen and forming a combination which gives great body and density to this binding material.

The bitumen under these conditions has a further influence, in that it serves as a protective film to the highly dispersed particles. Various bitumens differ in the degree in which they exercise protective properties, this difference being apparently in proportion to their viscosity or density; and there is a close relation between this property and the success achieved with them in the making of a sheet asphalt paving mixture. The more viscous the bitumen and the larger the amount of colloid material it contains, the thicker will be the film which adheres to or is adsorbed by the mineral aggregate, and, consequently, the greater cementing power of the bitumen which forms the thicker film.\*

Barber Asphalt Paving Co.,  
Philadelphia, Pa.

DANIEL T. PIERCE.

### Flotation Suit

On May 27, 1915, the hearings in the case of Minerals Separation, Ltd., vs. Miami Copper Company were concluded after a nine weeks' contest in the United States Court for the District of Delaware at Wilmington, presided over by the Hon. Judge Bradford. In view of the enormous industrial importance of this case, the following summary of the present status should be of very considerable interest:

When suit was first brought by Minerals Separation, the Miami Copper Company was merely technically liable to an infringement suit, owing to its use in an experimental plant, of a 60-ton Minerals Separation type of flotation machine. This first proceeding, in form of two separate suits, was based upon two of Minerals Separation patents—patent 835,120, for the use of "less than one per cent of oil," and patent 962,678, covering the use of soluble frothing agents.

About the first of August, 1914, the Miami company commenced experimenting upon a 300-ton plant with what is generally known as the Callow type of cell—a flotation device in which air bubbles are *not* introduced by agitation, as was done by mechanical beaters in the Minerals Separation machine, upon the use of which the original suit was brought.

The first suits were then withdrawn and a new suit in equity was instituted, alleging infringement of three of the Minerals Separation patents, the two above mentioned and a new one which had just been issued, 1,099,699. The claims of the latter cover the use specifically of aromatic hydroxyl compounds as frothing agents *in the cold and without acid*. The bill of complaint urged that the Miami Copper Company had infringed in the use of these three patents conjointly.

Interrogatories were filed by the complainant and were most frankly answered by the defendant.

It will be seen that the Miami suit introduces several features which were not present in the Hyde case.† This case was decided in favor of Minerals Separation in the lower court of Butte, but the decision was reversed in the Superior Court of San Francisco, and the case is now awaiting a hearing in the United States Supreme

\*Those who are interested in pursuing further the result of Mr. Richardson's investigations may be referred to the following articles: "A Unique Geophysical Phenomenon," *Journal of Physical Chemistry*, Vol. 19, No. 3. "Colloids in Their Relation to Bituminous Road Construction, the Asphalt Paving and Other Industries," *Technology Monthly and Harvard Engineering Journal*, Vol. II, No. 2. "The Theory of a Perfect Sheet Asphalt Surface," *Journal of Eng. and Ind. Chemistry*, June, 1915.

†See METALLURGICAL & CHEMICAL ENGINEERING, Vol. XII, p. 362 (June, 1914).



Court. In the Hyde case only patent 835,120 was at issue, and since the operations in that case had been carried on in a machine, employing agitation with mechanical beaters, the defense had largely to depend upon breaking down the validity of the patent for less than 1 per cent of oil (patent 835,120). The Superior Court in San Francisco decided that this patent was invalid in that the reduction of oil to a point less than 1 per cent had shown nothing new besides an economy in oil. In the Miami case it became, therefore, now incumbent upon the complainant to demonstrate to the court that some new effect, some new result other than mere economy, is produced when the oil is reduced to this extremely minute quantity, while the defendants had to show that in the use of less than 1 per cent of oil no effect that was not also attained by the prior-art processes, except mere economy, is produced in the operation of patent 835,120.

The pneumatic cells of the Miami process having no mechanical beaters or agitators, but having the finely divided air admitted through a porous bottom from blowers or fans, left open more of a question as to infringement, since the defendant company maintained that its mode of operation did not infringe any of the claims of the patents in suit. Upon the other hand, the witnesses of Minerals Separation, who had visited the Miami plant, testified that all of the agitation necessary to produce their agitation froth was found in certain centrifugal pumps, Pachuca tanks, etc., which formed adjuncts to the pneumatic cells, and that the cells themselves were in fact agitators.

The defendants, on the other hand, maintained that if some agitation froth were produced through the agency of such accessory apparatus it was negligible in quantity and was not utilized in the subsequent separation in the cells. To sustain this claim they introduced figures and assays in evidence tending to show that in the present operating plant the results were identically the same, when two sections of the mill were operated side by side, one section having the Pachuca in operation and the other section having the oil merely fed into the launders in which the feed to the flotation plant was flowing with no mechanical handling other than a bucket elevator.

In the demonstrations to establish the non-validity of the less than 1 per cent of oil patent the defendants exhibited to the court models of various prior-art machines, such as those of Carrie Everson, Froment, Kirby, etc., in which experiments were made in court, and concentrates produced with quantities of oil varying from  $\frac{1}{2}$  per cent up to 25 per cent of oil. On the other hand, the experts of Minerals Separation contended that the defendants' apparatus has no foundation whatever in the prior art, and that all such results were obtained by defendants through their availing themselves of present-day knowledge, and not of the engineering knowledge at the time of the patents or processes in question, and the complainants (Minerals Separation) exhibited their conception of the prior art, endeavoring to illustrate to the court how utterly these prior-art processes had failed to produce any commercial results except upon a laboratory scale. They maintained that not one of these so-called prior-art processes had actually been in successful commercial operation.

The display of models in the court room at the close of court was most interesting, when all these exhibits were seen together as the various deposits of complainant and defendant. Possibly the most interesting of the prior-art disclosures was the description of froth-producing experiments as described by three students of the University of California in *California Journal of Technology* of November, 1903, in which they clearly

set forth the distinction between the "lake effect" of the bulk oil (Elmore) process and the "foam effect" due to the "beating in" of air as in the Minerals Separation practice, describing the demonstration corresponding to the "bottle test" used as a field test as to the suitability of ores for treatment by the Minerals Separation engineers.

Possibly the most novel feature of the demonstrations was the use of a moving-picture film to illustrate certain laboratory experiments which had been made at a laboratory in New York. This, among other things, was to illustrate the action of air bubbles in their attraction for oiled and non-oiled mineral particles, and essentially to show that when particles were oiled with less than the Cattermole proportion, that is with less oil than is necessary to make them adhere, their affinity or attraction for the froth-producing air bubbles became effective, whereas it was stated to be a general law that particles oiled with sufficient oil to cause them to adhere had little or no attraction for air bubbles. The Miami experts showed by a similar set of experiments that the broad statements of the picture film were not sustained, and that there did not exist any actual difference in behavior of oiled and non-oiled particles as supposed by the Minerals Separation.

This discussion of the film constituted an important feature of the proceedings of the trial. The ingenious manner of observing and illustrating the action of air bubbles in a moving picture was devised by Dr. Wm. M. Grosvenor of New York.

The experimental demonstrations before the court were mostly in connection with patent 835,120, which covers the use of less than 1 per cent of frothing agent.

With reference to patent 926,678 the defense in argument contended that soluble frothing agents had been disclosed in previous patents, and with respect to patent 1,099,699 (covering flotation without acid and without heat) that the use of both acid and heat had been disclosed as optional in various prior patents, though the use of both acid and heat had become general in the application of flotation.

Mr. Henry D. Williams of New York, who had handled the case of Minerals Separation, made the principal argument for the plaintiff. He was followed by Mr. William Houston Kenyon, also of New York, in an able review of the case, with the legal citations.

Mr. Walter A. Scott of Chicago, who had the case for the Miami company, made the principal argument for the defense. He was followed by his law partner, Mr. Thomas F. Sheridan, who took up the legal citations. Mr. Scott had also handled the defense in the Hyde case, above referred to. He showed his wonderful grasp of the subject matter by the readiness with which he referred to the records of the previous, as well as the present case, in replying to Judge Bradford's numerous questions.

Dr. Adolph Liebman of London was chief expert for Minerals Separation, and Dr. Samuel P. Sadtler of Philadelphia for the Miami company. Upon each side were also some eight or ten engineers and metallurgists, many of whom had taken part in the Hyde case.

Mr. John Ballot, head of Minerals Separation, Ltd., who had come to America some time previous to the trial, was unfortunately unable to be present, owing to serious illness. Dr. S. Gregory, managing director of the American Minerals Separation Syndicate, represented the plaintiff by his presence.

Mr. R. C. Canby, consulting metallurgist, who had introduced flotation at the Miami plant, was present throughout the suit in the interest of the Miami company, and Mr. J. Park Channing, vice-president of the Miami Copper Company, was in almost constant attend-

ance, spending the larger part of each week in Wilmington.

The arguments upon both sides were good and very interesting. As Judge Bradford said in his closing remarks, he could see from the arguments that he was not going to be able to render a decision which would please both sides.

The decision will probably not be handed down until some time in the fall.

### Bakelite Suit Decision

The U. S. District Court, Eastern District of New York, has just rendered its decision in the case of General Bakelite Company versus George J. Nikolas. The decision is in favor of the General Bakelite Company, the bakelite patents in question being held valid and infringed. The case is not only of commercial importance, but very instructive in various of its legal and chemical aspects. A full review should therefore prove of considerable interest.

An infringement suit was started by the General Bakelite Company, plaintiff, against George J. Nikolas of Chicago, defendant, trading as George J. Nikolas & Company, varnish and lacquer manufacturers.

The counsels for the General Bakelite Company were Mr. Charles Neave of Fish, Richardson, Herrick & Neave, and Mr. C. P. Townsend, of Byrnes, Townsend & Brickenstein. Dr. Baekeland testified in his own behalf and also as chemical expert. Dr. Parker McIlhiney and Dr. A. H. Gotthelf testified for the plaintiff in relation to analytical work.

Judge Willard M. McEwen and Mr. William R. Rummel of Chicago acted as counsel for the defendant in conjunction with Pennie, Davis & Goldsborough of New York. Mr. K. P. McElroy of Washington acted as chemist and patent expert for the defendant in conjunction with Dr. Ludwig Saarbach of New York, and Mr. E. B. Stuart of Chicago.

The trial was conducted before Judge Thomas I. Chatfield, of the United States District Court, Eastern District of New York. The trial was held in open court and was begun on December 9, 1913. The testimony filled 1396 typewritten pages. The whole trial took about 23 days. The final argument for plaintiff was presented on February 20 to February 21, 1914. The decision was given on June 12, 1915.

The suit was started on the following United States patents:

Baekeland, "Varnish," No. 954,666, patented April 12, 1910; original application filed October 15, 1907, divided and this application filed November 22, 1909. The claims of this patent are as follows:

"1. A varnish containing a volatile organic solvent and a condensation product of a phenolic body and formaldehyde, said condensation product characterized by its capability of transformation under the action of heat into an insoluble and infusible body, and by the presence therein of a base condensing agent.

2. A varnish containing a volatile organic solvent and a condensation product of a phenolic body and formaldehyde, said condensation product characterized by its capability of transformation under the action of heat into an insoluble and infusing body, and by the presence therein of a base condensing agent in proportions not exceeding one-fifth of the equimolecular proportion of phenolic body employed."

Baekeland, "Varnish," No. 1,018,385, patented February 20, 1912, application filed March 14, 1911. The claims of this patent are as follows:

"1. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde substantially free from uncombined phenols and a solvent therefor, said solvent containing a readily volatile organic liquid, and another organic liquid which is immiscible with water but miscible with said solvent and of which the boiling point exceeds that of water.

2. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde and a solvent therefor, said solvent containing amyl alcohol and a readily volatile organic liquid.

3. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde substantially free from uncombined phenols and a solvent therefor, said solvent containing acetone and an organic liquid of which the boiling point exceeds that of water.

4. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde and a solvent therefor, said solvent containing acetone and amyl alcohol.

5. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde and a solvent therefor, said solvent containing a readily volatile organic liquid, and another organic liquid which is immiscible with water but miscible with said solvent, which is volatilizable without decomposition when heated at atmospheric pressures, and of which the boiling point exceeds that of water.

6. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde and a solvent therefor, said solvent containing acetone and an organic liquid which is volatilizable without decomposition when heated at atmospheric pressures, and of which the boiling point exceeds that of water."

Baekeland, "Varnish," No. 1,037,719, patented September 3, 1912, application filed March 14, 1911. The claims of this patent are as follows:

"1. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor, said solvent containing a liquid oxygen-compound of the aliphatic series, and a hydrocarbon.

2. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor, said solvent containing a liquid oxygen-compound of the aliphatic series, and a cyclic hydrocarbon.

3. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor, said solvent containing a liquid oxygen-compound of the aliphatic series, and a hydrocarbon of the benzol series.

4. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor, containing a liquid oxygen-compound of the aliphatic series and a hydrocarbon, and another organic body soluble in said solvent or miscible therewith.

5. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor, said solvent containing acetone and a hydrocarbon.

6. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor, said solvent containing acetone and a cyclic hydrocarbon.

7. As a new composition of matter, a varnish comprising a condensation product of phenols and formaldehyde, transformable by heat into an infusible body and a solvent therefor containing an oxygen-compound of the aliphatic series and a hydrocarbon, and Chinese oil or tung oil."

The counsel for the defendant presented no less than 47 prior patents, aside from many literature references, each one of which was alleged by the defense to contain prior disclosures; but the decision rejected all these allegations and held that the three Baekeland patents in suit are valid and infringed. The decree covers about sixty pages; it reviews carefully the details of the testimony as well as all the arguments of the defense.

From Judge Chatfield's decision we quote the following:

The testimony shows commercially successful accomplishments, as well as scientific investigation by the patentee in this country, and his appearance and testimony upon the witness stand have plainly shown mental capacity, scientific knowledge and deductive ability which would accord with and be expected as the necessary foundation for such investigations and experimental operations as those involved in practicing or advancing the art and processes set forth in the patents as to which the present litigation has arisen.

The defendant is a practical manufacturer of varnishes in the City of Chicago, who disclaims knowledge of chemistry as a science, and who testified that in the mixture and



treatment of chemicals during the manufacture of varnish, he judged the reaction and formed all his conclusions from experience and appearances, without regard to the nature of the reaction taking place.

The plaintiff alleges infringement by the sale upon the open market of certain varnishes known as bedstead filler or gold lacquer or satin A. P. lacquer, of which admitted samples have been produced by the defendant during the course of the trial.

At the outset of the case, considerable point was made of the issue of infringement, by reason of the fact that the sample produced by the plaintiff, and obtained from a store used by the defendant as an agency in Brooklyn, was claimed by the defendant to be different in appearance from anything manufactured by him. The sample was therefore disavowed by the defendant as his product. The difference in appearance was never satisfactorily explained, but the chemical analysis of the contents and the analyses of the samples produced by the defendant were such that no issue as to the actual resemblance of the defendant's commercial product and the article described by the patents exists.

The defendant, however, contends that he does not do or use anything in the manufacture of his varnish which would be an infringement of the plaintiff's patents, and, in fact, denies the use of materials which the plaintiff, from analysis of the product, contends must be employed by him. This issue will be discussed in connection with the patents of the prior art, and we will take up at once the patents in suit and the patentee's work in connection therewith....

Then follows a systematic review of the prior art as alleged by defendant to contain disclosures annulling the patentability of the claims of the Baekeland patents, and a comparison of these disclosures, with the claims of the Baekeland patents in suit, as well as other Baekeland patents relating thereto.

It was plainly old in the art to make pyroxylin varnishes and varnishes of phenolic condensation products. But each of these varnishes, and each condensation product, had individual characteristics, and the patents in suit involve differences in the chemical process or processes of manufacture by which the particular product, claimed in the patent as novel, is to be produced.

The defendant claims that this product, to be used in the making of varnish, was nothing more than the resin which the patentee had sought to patent for use as a varnish, and he urges, therefore, that the varnish patents themselves are invalid, citing *Underwood v. Gerber*, 149 U. S. 224.

He attacks further Claim 1, because the patentee is said to have acquiesced in the rejection by the Patent Office of this claim when first presented.

The application for patent 942,809, which was a renewal of application 397,560, contained the claim filed upon the 15th of October, 1907, for a varnish, and the defense claims that the rejection of the varnish claims in the condensation product patent was acquiesced in by Baekeland, and that he therefore could not divide the application and restate the claim.

Examination of the file wrapper shows that this rejection was merely because of the incompatibility, under the rules of the Patent Office, of a claim for varnish in the same patent with a claim for the condensation product with which the varnish is to be made, or a claim for the method of making that product.

Claim 2 is said to be invalid in that the specifications as originally presented, and even as finally contained in the allowed patent, do not show the rule of proportion set forth in the language "not exceeding one-fifth of the equal molecular proportion of phenol body employed." During the trial much testimony was devoted to an explanation of the meaning of "equal molecular proportion" and computation of the amount of ingredients set forth in the various patents discussed in the record.

Inasmuch as there is no dispute as to the real meaning of the phrase or as to the molecular weight of the ingredients, or as to the quantity represented by one-fifth of the phenolic body expressed in terms of molecular weight, and so long as there is no dispute as to the percentage of the whole article represented thereby, we need only look to the specifications in order to find if the language of this claim corresponds to a proposition explained in the specifications.

The patentee, when referring to the use of base, and speaking of ammonia or caustic soda as an illustration, says that so small a proportion of the base as one-half per cent of the weight of phenol, that is 1/200 by weight, and in other cases an increased amount rarely reaching 10 per cent by weight of the phenol, is sufficient. This base is, however, to be calculated from that which actually remains

as such in the product or the varnish and the definite proportion contained in the claim was inserted therein after the Patent Office compelled the patentee to limit his claim of invention (but not the statement of his original experimentation or his present conclusion) to matters which the Patent Office considered new over the De Laire, Story and Luft patents.

Under these circumstances, the Court cannot see why the claims should be invalid because at the time of filing the application the patentee did not sufficiently limit the language in his claims so as to avoid interference with other patents which, however, did not disclose the precise matter ultimately proving to be that intended to be claimed as invention by the applicant, and which had been in his mind from the time of his application. Thus the small amount of base which Dr. Baekeland finds would universally produce the result desired, was not disclosed by any of the prior patents, up to the time the application by Baekeland was filed.

Subsequently a certificate of addition to the Story (French) patent was filed upon the 29th day of September, 1908, and therefrom the defendant suggests that Baekeland learned how to state the claim which he had previously been trying to formulate. But the question of patentability could not rest upon literary plagiarism even if that were shown, and the testimony in the case would indicate rather that the Story addition was an attempt to secure the French rights for the same variation from the original Story patent as were being claimed by Baekeland in the United States, even if there were reason to suppose that Baekeland had seen this addition to the Story (French) patent, which was not published until February 25, 1909.

This would not prove that Story was entitled to claim the invention over that claimed by Baekeland, and if Baekeland's invention was in fact the same as that described in the Story addition, then Baekeland would be entitled, on application to the Patent Office, to have the claim issued even in substantially the same language as that described by Story.

The defendant does not show that Story was the inventor rather than Baekeland, he merely suggests that Story's patent solicitor produced a statement of the claim in such a form that Baekeland could see at once that, stated in the same way, his invention was made valid over the prior art and would meet with the approval of the Patent Office.

But, as a matter of fact, the defense does not even make out its accusation of plagiarism, as there is nothing to show that Dr. Baekeland had the Story addition before him or called to his knowledge prior to the time when he realized the way in which to make a definite statement of what he claimed as novel in his patent over the Story or De Laire patents themselves.

The defense to the second and third patents is substantially the same as that to the first, but with the added proposition that double solvents were old in the art and that the particular double solvents claimed in the third patent were in fact but a variety of those shown in the second.

As to the last proposition which is urged (that benzol or toluol with amyl alcohol would be one of the possible components referred to in the second patent, when it suggests the use of a solvent, immiscible with water and having a boiling point higher than that of water, with one of easily volatile solvents at lower temperatures) the defendant's claim is that thereby the patentee attempts double patenting or extension of the time of protection beyond that shown by the second patent. But even though the third patent should be held to cover nothing more than one of the components disclosed by the second patent, and if the third patent should therefore be void for anything more than the period protected by the second, the defendant herein would still be an infringer of the second patent and liable.

As a matter of fact, however, the third patent is not invalid in this sense. The second patent does not teach nor show the combination of a hydrocarbon with a solvent of the aliphatic series, having the qualities of and volatilizing at the temperatures described. The testimony of the expert varnish makers in the case shows that the use of these two particular solvents would be not only an accident, but substantially improbable except as a casual experiment, and the precise nature of the product covered by the third patent is shown therein to be adapted for a particular use, and would seem to be a patentable improvement over the combination described in patent number two.

We come back, therefore, to the main defenses based upon the prior art.

The defendant attempted to show non-infringement upon his own testimony that he added no base to the commercial carbolic acid and the commercial formaldehyde solution



which he employs in making his varnish. But analysis by both the defendant's and the plaintiff's experts showed the presence of ammonia by what is called the Kjeldahl method, which shows the quantity of nitrogen and accounts for any ammonia that may have been present as a part of this nitrogenous body.

By another analysis, the plaintiff's expert, whose results compared generally closely to similar analyses by the defendant's expert, found free ammonia amounting to 13/100 per cent of the solid residue. The defendant's expert failed to take into account the combination of ammonia and formaldehyde to form hexamethylenetetramine a non-volatile base from which ammonia would not be driven off by boiling with caustic soda.

The analyses further showed that the defendant's products contained pure phenol and ammonia, and the testimony of the case shows definitely that ammonia is not found in commercial carbolic acid. But orthocresol, metacresol and paracresol, as well as pyridin are found in commercial carbolic acid. Pyridin shows by the Nessler test no trace of ammonia and yet would give by the Kjeldahl test evidence of the presence of nitrogen. Likewise by the Kjeldahl method, ammonia would be found and be calculated as nitrogen.

Commercial carbolic acid is mostly cresol, with possibly a small amount of true phenol. As true phenol or hydroxybenzol reacts more easily with formaldehyde than does paracresol or orthocresol, the fact that free phenol is found in the defendant's varnish, and that no cresols were found, would indicate that the defendant's varnish was made from phenol rather than commercial carbolic acid, and that the ammonia present must have been in some form added as a base.

While the defendant has testified to certain purchases of commercial carbolic acid, and also certain purchases of crystalline phenol, he has not testified to the use of any material which would satisfactorily account for the product shown by analysis, and it must be held that he is either making a product which infringes the plaintiff's patent, and has not disclosed the methods of so doing, or that he has added some material of which he does not know the contents himself, but which contains products that do infringe the patent.

It is no defense to a charge of infringement of a patent for a product produced by some chemical process, to assert ignorance of the reactions which take place, and thus claim the right to combine substances which on analysis are shown to cause the reactions of the process leading to the patented product, and to obtain that product itself by methods shown to be those of the patent, even though never before understood until testified to upon the trial.

If a person should attempt to excuse infringement of a patent calling for the use of iron or steel in the making of a device, by suggesting that he did not know what iron or steel was, and that he merely used a hard metallic substance which he purchased from a certain manufacturer and which did the work, it can be seen where such a doctrine would lead.

The defendant also contends that the amount of base shown by the defendant's chemist is much less than the smallest amount stated in the plaintiff's patent to be sufficient to meet the discovery therein contained. But the plaintiff's expert finds ammonia approximating 13/100 per cent of the solid residue which is within the quantity referred to in the specification.

Much of the discussion raised by the defendant with reference to the validity of the patent, both from the standpoint of the disclosures in the plaintiff's former applications and patents and also in following up the suggestions of the patents of the prior art, arise from the nature of the claims and of the invention.

It will, of course, be assumed that no chemical reaction can be patented as such. A natural product, such as ordinary salt (NaCl), could not be made the basis of a patent, nor could a discovery of the chemical reactions by which salt was formed in nature, from sodium and chlorine, be patented as a process. But if artificial salt, as a chemical substance, could be distinguished from natural salt, and if some one discovered a way to make artificial salt, he could patent the method or process, if it were novel. Provided he was the first one to produce the substance, he could patent the product as something useful in commerce or in the arts.

So it is conceivable that some gum or natural substance like shellac or amber might be found, composed of phenol, formaldehyde and a base, and transformed by heat into an insoluble and infusible substance. If such a product had been known prior to the plaintiff's patents, the plaintiff could have obtained no patent, if his product was identical and indistinguishable from the natural substance, but he would have been limited to a patent for a process.

But at a time when the only product of phenol and formaldehyde, known and described *with understanding and definiteness*, was a permanently fusible and permanently soluble gum, the discovery of a method of rendering this product insoluble and infusible was patentable, and provided the product could be certainly identified and distinguished from the former and known products, it could be patented as well as a combination of such substances in certain relations or proportions.

If the use of an excess of formaldehyde was overcome by the use of a large amount of base, and the base in turn removed by precipitation into an acid salt, and if the product was not identifiable or was not available for any known purpose, no patent could be issued for the process (which would be mere chemical reactions) nor for the product (see Reychler and Kleebert), and certainly the combination of that product with some other substances to form a useful article like a varnish, is inconceivable.

The patents in suit are based upon the earlier patents of Baekeland for a method of producing the phenolic gum and also his patents for the condensation product produced by the patented method. But when he attempts to make a varnish which consists of a combination based upon and making use of the patentable method of preparing the condensation product, and also upon the patentable substance itself, he has a new substance which is itself patentable. As in the case of a patentable mechanical device, this consists of more than a mere aggregation of parts.

Considering the last two patents in suit for a moment, the defendant claims that they are invalid because they show merely the use of a double solvent with a gum or product which is capable of solution for varnish purposes, which is nothing more than the ordinary defense of aggregation with respect to a combination of mechanical parts. If the use of these solvents with this particular phenolic gum presents a substance having qualities that are different from those of any other compound or substance previously used for the same purpose, it is no defense to the patent to suggest that the physical or chemical processes involved in the mixing and drying or setting of the varnish are the same as those involved in the mixing, drying or setting of a varnish which would produce different results and show different qualities.

The combination disclosed in the Baekeland patents is new for varnish purposes. It has new qualities, and meets old needs in a new way. The behavior and purposes of the double solvents, and the way in which the varnish passes through the physical and chemical changes, are, of course, not patentable, any more than the suggestion that the water present is eliminated in the form of vapor would be novel or distinguish the product from other substances. If, however, water or volatile solvents are evaporated, the patentability of the combination from which the water is produced would not be affected by the age of the world's appreciation of the principle of evaporation.

So with the first patent in suit, when we consider the various patents of the prior art by which condensation products, showing either an excess of phenol or an excess of formaldehyde, or condensation by the aid of a large amount of base, or by the acidification of the base and its removal in the form of non-soluble salts, or if we consider the possibility of obtaining a huge mass of insoluble and infusible material, of irregular shape, by a violent expulsion of steam or gas and a consequent spongy or porous form of the product, or if we consider the production of an insoluble and infusible film in small quantities upon a glass plate or in a test tube, or even if we found the product such as was shown in the Story (English) patent, where, by long application of heat a reddish or red-colored film could be produced, or if we consider a condensation product which, while capable of use as a varnish, remains permanently fusible and soluble (such as that distinguished by the novolak type) we nowhere approach to the particular condensation product and the particular combination, for use as a varnish, by which it is possible to certainly, easily and accurately begin with a condensation product that in combination with certain defined solvents will produce a varnish which with short subjection to moderate heat will produce a colorless, infusible, insoluble and useful lacquer film of the sort desired for use in the arts and which in certain definitely specified combinations possesses the qualities required where the surface is to be subjected to the influence of an electric current, under conditions where moisture may be absorbed or encountered.

It is unnecessary to go through the patents presented in the prior art in detail.

It is sufficient to say that in none of the earlier Baekeland patents was a varnish combination disclosed which was like that in the patents in suit, even though Baekeland in some of the earlier patents taught that his particular condensation product was available as a varnish. Nor did

any of the earlier Baekeland patents or the patents of the prior art shown in circles 2 and 3, produce the infusible and insoluble substance of the Baekeland patents shown in circles 11 and 13.

The Story (English) patent, as has been seen, presented an acid, rather than a basic condensation product, in cases where pure phenol was used; a large amount of heat or long evaporation was necessary to produce the insoluble or infusible film with the reddish tinge, while the product that Story considered available for varnish purposes was that containing the acid salts.

Such other patents as those set forth in class 15 upon the diagram, present non-phenolic or non-reactive varnishes or resins which have nothing to do with the combinations of the patents in suit, except as they may use double solvents or may set forth similar chemical reactions, or may, with the knowledge of those patents, as well as of the Baekeland patents, indicate how an exchange of substance might, by employment of the same chemical reactions as before, produce the Baekeland results. But such patents are not anticipations, nor would they be infringements of the Baekeland patents in suit, and we can therefore dismiss them, as in each case they were substantially dismissed by the defendant's expert upon the trial, by saying that no one of them showed in its entirety the precise varnish or combination of any of the three patents in suit. Even if it does not require invention to trace the resemblances between these patents and the Baekeland patents in suit, or to produce similar results by substitution of known products for those products which were different in these prior art patents, and even if we do not concede to the defendant's expert invention in tracing the points of resemblance and difference, it is evident that his recognition of these points does not raise them to the dignity of defenses, nor are they anticipations of the Baekeland patents.

The doctrine of Underwood v. Gerber (supra) is presented as authority for the claim of invalidity as to the patents in suit, because it is said that in patent 942,809, Baekeland disclosed the same form of varnish resin, and that no patentable novelty is shown in merely combining that resin with a solvent to make a varnish.

The discussion already had shows the difference between the case at bar and Underwood v. Gerber (supra), where a patented or claimed product was subsequently used as an application for the surfacing of paper. But the discussion already had shows further that patent 942,809 describes merely the process or method of producing a patentable substance, while Claim 8 describes this condensation in such general form that the description in patent 954,666, of a varnish made therewith, would still be possible as a combination, even though Dr. Baekeland might not be able to patent a second time the condensation product produced by the presence of a base condensing agent in proportions not to exceed one-fifth of the equal molecular proportion of phenolic body employed after describing that condensation product in his previous patent, 942,809, for which the application was that from which the new application was divided and re-filed.

The first patent in suit was based upon the application for 942,809, was never abandoned and was not anticipated by the subsequent separate allowances of 942,809 for one of the ingredients of the new and patentable substance which was useful commercially as a varnish.

Claim 2 of patent 954,666 is therefore valid as the definite description of the combination specifically based upon the product patented in 942,809, while Claim 1 of patent 954,666 is valid as a general description of a new form of varnish which can be produced by the methods of the specification and which is in more detail identified in Claim 2.

The patents will therefore be held valid and infringed and the plaintiff may have a decree.

The Cobalt district, Canada, has recently been visited by agents of companies operating in the Gold Coast, Africa, seeking miners for service at that place.

The manufacture of ceramic wares in the United States is a matter receiving attention at this time. According to *Technical Paper 99* issued by the Bureau of Mines, American manufacturers have an opportunity to secure domestic trade on account of conditions created by the European war. Attention is directed, however, to the fact that the standard of American production must be maintained at the highest if permanent business is to result. The restoration of European trade in this country will require much time and money, but competition may be expected as soon as European makers can again enter the field.

## Court of Appeals Decision in Nickel-Chromium Resistor Suit

In the suit of the Hoskins Manufacturing Company against the General Electric Company for infringement of the A. L. Marsh patent 811,859 (Feb. 4, 1906) the District Court of the United States for the Northern District of Illinois, Eastern Division, had sustained the patent and found it to be infringed by the General Electric Company. The latter company thereupon appealed. The United States Circuit Court of Appeals for the Seventh Circuit has now affirmed the degree of the District Court and decided that "appellant's [General Electric Company's] use of the alloy [calorite] is an infringement of the Marsh patent and should be restrained."

The case was heard before Circuit Judges Baker, Kohlsaat and Mack. The decision is written by Judge Kohlsaat.

The strongest reference brought forward against the validity of the Marsh patent was that of the English patent of Emile Placet, No. 202, Nov. 21, 1896.

"This patent was not before the Examiner, nor was it known to Marsh at the time of his invention so far as the record shows. It relates to a method of introducing pure chromium into metals and alloys in a state of fusion. Speaking of pure chromium, Placet says, 'This chromium is absolutely pure. It improves all metals and alloys with which it is mixed by imparting to them the qualities peculiar to itself. It renders them harder, more resistant to shocks, tension, and friction, and also renders them more proof against the destructive action of the air, moisture, acids, and high temperatures.' 'Chromium,' he says again, 'renders metals and alloys more resistant than heretofore to high temperatures, which renders them highly suitable for the manufacture of tuyeres, hearths, fire-arms, etc.' Again he says, 'Chromium increases the electrical resistance of manganese, ferro-manganese, ferro-nickel, and other metals employed in the manufacture of conductors of high electrical resistance.'"

"Appellant [General Electric Co.] sought to purchase the patent in suit, and, failing, took appellee's [Hoskins Mfg. Co.'s] said alloy of nickel and chromium and added a small quantity of manganese and 15 per cent of iron, admittedly for the purpose of coming within the alleged disclosures of the Placet patent. These additions, appellee contends, served merely as diluents and in no appreciable degree affected the characteristics of the alloy. This element is termed calorite, and contains nickel 65 per cent, iron 15 per cent, chromium 12 per cent and manganese 8 per cent. For appellee it is insisted that, for purposes of durability as an electrical resistance element, it is practically identical with its own element.

"Appellant contends that the claims in suit are narrow and must be strictly construed, that its own resistance element does not infringe the claims as they read, that, construed in the light of the prior art and the file wrapper, the claims cannot cover appellant's element, which comes within the Placet patent and Marsh's abandoned claim four, although Placet shows no alloy, used as a high resistance element, having less than 56 per cent of iron. The patent drawing is that of a rheostat, the resistance element of which is the alloy of the patent. The patentee claims a resistance element as distinguished from a material possessed of high resistivity."

From Judge Kohlsaat's opinion we quote the following extracts:

"The invention of toasters, heaters, electrical ironers and the like had begun, and it was apparent that in these as well as in the art generally the need of conductors having great durability when subjected to heat was at hand. This involved also substances which possessed the property of ductility to a degree sufficient to permit the drawing of filaments, strands, wire, etc., for use as electrical conductors. Platinum alone was then recognized as an enduring material suitable for conductors which were required to be subjected to great heat. Its cost prohibited its commercial use. Consequently the Marsh discovery was hailed as an available substitute. It was and is a most valuable resistance material. It lasts when subjected to heat from 800 deg. to 1000 deg. C. one hundred and fifty times as long as anything in the prior art, except platinum, unless Placet may be construed to have disclosed the concept, for unless



Placet anticipates Marsh's material as an electrical resistance element it is not anticipated. It will be seen from Placet's English patent that the patentee leaves it to others to ascertain by experiment products of chromium and metals in alloy suitable for high resistance and those disclosing the element of resistance to high temperatures. Placet's discoveries were before the public about eleven years before Marsh's patent was granted, from which fact it may be at least conjectured that the valuable resistance and duration properties as resistance elements which appellant finds disclosed therein, were not ostentatiously in evidence. Now, the law is well settled that in order to anticipate a later invention, the prior description must be such as to show that the article described in the patent can be certainly arrived at by following the prior description without the assistance of local knowledge or local prior use in the locality where the description is published, and without experimentation."

"Placet's statements, if taken at their face value, turn out to be untrue in many cases when subjected to experiment. It is not true that when alloyed with metal, chromium always brings to the alloy its own distinctive specific properties." Illustrations are given showing that resistivity is not increased in all cases by chromium, that the melting point is not increased in all cases by chromium and that durability is not measured by resistivity.

"There are many elements which affect the efficiency of a resistance element in an electrical circuit. The melting point, while a limit to a material's electrical resistance properties as an element, is not determinative thereof. Resistance to oxidation is an important feature. These are probably the chief factors. There must also be taken into account the temperature co-efficient, the condition of the oxide scale on the resistance material as to density, electrical conductivity, volatility, uniformity of composition of resistance material, and a number of other things. The durability of the Marsh alloy at a heat of 800 deg. to 1000 deg. C., Marsh fixes at from 200 to 2000 times that of any resistance material in the prior art. Can it be supposed that Placet, had he known of its availability as an electrical resistance element, would have overlooked it? or that all those who utilized it afterwards for the manufacture of watch springs and wheels, steel, pig-iron and precision apparatus and light filament would have passed by, as of no consequence, this great substitute for platinum, had Placet suggested its value to them, or made them understand what it was? Placet could no more claim this resistance element, as disclosed by Marsh, than could Ostermann and LaCroix with their watch spring material.

"For eleven years this device of Marsh lay hidden as a gem in its Placet matrix. There it might yet be lying had not Marsh found it and made it public. Certainly it never occurred to Placet that this chromium-nickel alloy would produce a rival to platinum as a resistance element at a cost and under conditions which made it an available article of commerce."

"It is evident that Placet and the other prior-art and prior-publication references fell far short of disclosing even to those skilled in the art, the subject matter of the patent in suit.

"In his argument before the Examiner, shown in the file wrapper and contents, Marsh by his attorneys says he 'does not claim to have been the first to make the alloy itself, but to have discovered that such alloys possess certain properties adapting them for a new field of usefulness.' Again appellee says, 'Some of the most important inventions have consisted in the practical application of the discovery of a new property of matter and this invention is of that class.' And again, 'The novelty of the patent in suit consists in discovering a new use for the chromium-nickel alloy in which is produced most extraordinary and unexpected results.' And again, 'the basis of the patent is the discovery that a resistance element of the composition specified is suitable for all-round use in the various situations in which such elements are desirable.' Thus, the main feature of the patent relied upon as new is the fact that Marsh found by experiment that the alloy of the patent combined with great resistivity, marvelous durability, second only to platinum, under conditions which made its production commercially practicable. Placet merely says chromium renders certain metals more resistant to high temperature, that is, it increases the melting point in some cases—a very different thing from durability. At most, he is speaking of externally applied heat, which is no criterion for durability under internally developed heat."

"If this discovery is to be judged by its contribution to the electrical art, it is entitled to be held to be measurably broad within certain lines and as such entitled to a reasonable degree of equivalents—not necessarily equivalency as found in chemical structures but, as was said in Treibacher

Chemische Werke, etc., v. Roessler & Hasslacher Chemical Co.,<sup>1</sup> supra, equivalency in 'functional efficiency.'

"Appellant's calorite consists in substance of appellee's alloy plus 15 per cent of iron and 8 per cent of manganese. It will be remembered that the patent specification says 'Iron, on the other hand, is readily oxidizable and will not answer my purpose when alloyed with a metal of the chromium group.' Placet speaks of the beneficial effect of an alloy consisting of chromium and ferro-nickel. Appellant claims to have brought itself within this alloy and within appellee's alleged abandoned claim 4. But Placet's alloy contained not less than 56 per cent of iron. It is evident that appellee was advised of the tendency of iron to oxidation. While possessed of high resistivity and high melting point, its duration at 1000 deg. C. is only nine minutes. Manifestly, in looking for an element possessing high specific resistance, he was awake to the necessity of such an element as had also the property of high durability. Very naturally he did not want a metal which endured at 1000 deg. C. for only nine minutes. We deem it a fair deduction from the evidence that Marsh was not thinking of a diluent of iron but of iron as a substitute for nickel, as a body for his alloy. From the record it appears that for the purpose of an all around element of great specific resistivity, including the essential companion property of endurance or resistance to the encroachment of high temperature, etc., 15 per cent of iron has no appreciable effect on a chromium and nickel alloy. Iron was supposed to increase the quality of ductility. Manganese was supposed to aid in deoxidation and refining. These elements were added to appellant's alloy, after it had analyzed two specimens of appellee's material and seem to have been added in the attempt to bring calorite within the Placet description and to avoid infringement of Marsh; but as above stated, Placet's ferro-nickel alloy contained 56 per cent iron. For all practical purposes for use in electric heating and cooking appliances and other devices employing high temperatures, the two resistance elements are equivalent. The object in increasing ductility was for the purpose of facilitating the process of drawing the alloy into strips, filaments, etc.

"As a matter of fact, appellant's resistance material is to all intents and purposes identical with that of appellee's. Its resistivity, durability, melting point, temperature coefficient, resistance to oxidation, ductility and appearance, practically coincide with that of Marsh. Appellee's element is sufficiently ductile for the uses to which it is put, as shown by the Hansen diagram above alluded to. The 15 per cent of iron is apparently lost, while the manganese makes no impression. Thus it is apparent that iron and manganese serve no purpose other than as diluents and as fictitious bases upon which to construct a claim for non-meritorious distinctions between the composition of the two alloys. Neither composition is new. When applied as electrical resistance elements, the results are identical, as is the appearance of the two. There is no other dissimilarity than the presence of small and inconsequential ingredients of iron and manganese in appellant's alloy. The new use is the same."

## The Western Metallurgical Field

### Colorado Manganese for the Chemical Trade

What appears to be an important supply of high-grade manganese ore in the United States, suitable more for industrial uses than for making ferromanganese, is being developed in San Miguel county, Colorado. When first discovered, the ore was submitted to certain interests in the steel trade, but was subsequently found to meet the requirements of the battery and glass trades, and is now being used for such purposes. It is claimed that large shipments can be made averaging 85 per cent MnO<sub>2</sub>, with less than 1 per cent iron. Manganese ore of this character has been imported from Turkey; but foreign shipments have been of uncertain delivery, and an opportunity appears for the creation of a good demand for a domestic product. The Colorado Manganese Mining & Smelting Company, which owns ten claims from which ore is now being shipped, expects to produce at the rate of about 750 tons per month. The property is located in Dry Creek Basin, San Miguel county, Colorado, and the ore is hauled 40 miles to the railroad at Placerville.

<sup>1</sup>See pages 135 and 145 of our March issue, 1915.—Editor.



### Sale of Stratton's Independence

With the sale of Stratton's Independence, Ltd., to the Portland Gold Mining Company, a most interesting chapter in Cripple Creek metallurgy is closed. Stratton's discovery and development of the Independence mine was one of the brilliant features of the early days of America's premier gold district. The subsequent sale of the property to British investors brought the property into world-wide prominence. From a metallurgical point of view, however, the chief interest centers in the successful treatment of the old mine dump, estimated to contain about 1,000,000 tons of ore worth about \$3 per ton. Based on an exhaustive investigation of the tonnage, value and most economic treatment of this dump, Mr. Philip Argall represented that with a cyanide mill of 10,000 tons monthly capacity, the ore could be treated at a cost of \$1.50 per ton, yielding a net profit of \$1 per ton. The annual reports of the company, which have been abstracted in this journal, indicate with what precision the estimates were made and how closely they were approximated by actual results during the life of the company. The estimated profits have been slightly exceeded by the actual returns to stockholders. Mr. Argall's venture was the first in the successful cyanidation of low-grade Cripple Creek ores. In general, the methods he employed have since been adopted by other companies treating those ores locally. Special methods introduced from time to time have not proved of sufficient merit to make their use permanent. The success of the venture should encourage the company to seek other problems in which the same careful preliminary investigation can show the same probable profit.

### Repairing Metallurgical Furnaces with Air Guns

Recently some interest has been aroused in the proposed use of a compressed-air gun for making repairs to metallurgical furnaces in which the linings are subject to deterioration at certain points. Inquiry among western smelter metallurgists reveals the fact that the idea is now wholly new, and has been tried experimentally. Apparently the idea occurred to a number of men about the same time, each recognizing the possibility of projecting a semi-fluid mixture of refractory material against the wall where repair was needed. An air gun for this purpose was tried at the Steptoe smelter at the time Mr. Sorensen was superintendent. At the Garfield smelter a similar device was used, made of 4-in. pipe connected with air under 100-lb. pressure and a supply of silica, with the idea of carrying the latter across the furnace. A similar scheme was contemplated by Mr. D. C. Smith, at Campo Seco; but a change in smelting practice occurring before the plan could be tried, it was rendered unnecessary. The idea appeared attractive because the repair mixture could be applied directly where needed, eliminating the waste incurred in hand work.

Since smelters have generally adopted the practice of charging reverberatory furnaces along the side walls instead of through hoppers placed centrally in the roof, the necessity for repairs to the side walls of such furnaces is no longer of great importance. The point of greatest deterioration is in the roof about 20 ft. back of the burner, and when this becomes too thin the furnace is shut down and the roof rebuilt at that point. Under present conditions of operation, therefore, the air gun would find no application for reverberatory furnaces.

In copper converters and casting furnaces, however, there might be a useful field for the device, especially of the type recently patented in which a high-temperature torch is combined with the air gun. The proposed

method of operation is to comminute the refractory material of which the lining is formed, and apply it continuously in small quantities at high velocity, at the same time subjecting it to incipient fusion by means of the torch combined with the gun. The result is said to be a lining which is vitreous, homogeneous and dense throughout, fused into form at a higher temperature than that at which the furnace is normally operated. The present methods of repairing basic-lined converters consists in applying a mixture of ground magnesite and water glass with a long-handled iron spoon, or by means of a tube and plunger, the former being filled with as much of the mixture as is required and the charge pushed into place by the plunger. In casting furnaces the roof requires repairs about every six months, and while the furnace is closed for these repairs, the side linings along the slag line also are patched.

### The Base-Metal Situation

The stimulating effect of the zinc market on ore production and treatment is strongly in evidence. The Joplin district especially is unusually active, record prices for "jack" being established on succeeding days. For the week ended June 12, the high price of \$135 per ton for 60 per cent concentrate showed an increase of \$25 per ton as compared with the previous week. Special grades brought a premium of \$3 per ton. Lead ore reached the record price of \$75 per ton, and calamine brought \$82 per ton on a basis of 40 per cent metallic zinc.

A zinc smelter at Bruce, Kan., which has been idle for eight years, is to be put in operation. At Joplin it is reported that the Joplin Separating Company is to build a small retort plant to be operated in conjunction with the concentrator. The Delta Lead and Zinc Company, which has operated a mill at Spring City, has completed a second mill of 150-tons capacity, and several mining operators have resumed work and are shipping ore to custom mills. Romantic tales are even told of feeble old men and young children culling dumps and making startling profits. The prosperity of the district extends to miners and smeltermen, wages having been advanced materially. At the Bartlesville smelters the wages of employees have been advanced 15 per cent.

Utah lead smelters are reported operating at capacity on ores already under contract. No new contracts are being made at the present market prices for lead, and those operators who have in the past refused to sign contracts will be unable to take advantage of the rise in price.

Quicksilver is being produced by the Nevada Cinnabar Company at Ione, Nev., at the rate of about sixty flasks per week, and properties in California, Nevada and Texas that were unable to operate profitably when quicksilver was quoted at \$35 to \$40 per flask, are reported to be resuming operations.

### Company Reports

The thirteenth annual report of the **Tonopah Mining Company of Nevada**, for the year ended February 28, 1915, shows the results of milling 143,432 dry tons of ore assaying 0.246 oz. gold and 21.22 oz. silver per ton. The costs were as follows: Mining and handling dump ore, \$4.40 per ton; milling, \$2.96; freight, \$0.74; marketing mill products, \$0.41; total, \$8.51 per ton. Metal losses in milling and refining amounted to \$1.23 per ton, leaving a profit of \$6.51 per ton. The average gross value of ore milled was \$16.25. Several radical changes were made in mill operation. It was found that the filter plant was not making a satisfactory recovery of dissolved metal, and the extraction from sand product was not as good as from slime. Filter presses were con-

sidered, but the cost for a suitable plant, including changes that would have to be made for all-slime treatment, would amount to \$100,000. In addition \$6000 would have to be spent for additional water supply. Finally, after considering other methods, it was decided to adopt all-sliming and decantation, which was done at a cost of \$38,000. Extraction has improved, resulting in the highest recoveries in the history of the plant and the lowest total costs. The reduction in cost due to the changes, during ten months of operation, amounted to 14.4 per cent. The company owns 83 1/3 per cent of the stock of the Tonopah Placers Company, operating three dredges at Breckenridge, Col. The option on property of the Eden Mining Company, Nicaragua, was exercised in January, 1915. Sufficient ore has been developed to warrant the erection of a 100-ton unit of a mill which is expected to be in operation within a year. A two-year option has been taken on the property of the Mizpah Extension Company of Tonopah. The Tonopah Placers Company dredged 2,995,256 cu. yd. of earth, producing 22,542 oz. gold and 4781 oz. silver. The value per yard was \$0.155 and the cost \$0.096.

The annual report of the **Tonopah Belmont Development Company** for the year ended Feb. 28, 1915, shows marked improvement in milling operations with attendant reduction in costs. The mill treated 181,424 dry tons of ore assaying 0.2336 oz. gold and 22.3 oz. silver per ton, having an average value of \$16.72 per ton. Total milling cost was \$2.564 as compared with \$3.049 in the preceding year. The cost per ton for labor was \$0.419; supplies, \$1.318; power, \$0.419. In the previous year the respective costs for these items were \$0.462, \$1.604 and \$0.494. The cost per ton for chemicals was: cyanide, \$0.601; zinc, \$0.0737; lime, \$0.0416. The average extraction of the tonnage milled was 95.78 per cent of the gold and 91.81 per cent of the silver, or a combined extraction of 92.99 per cent. Due to the more refractory nature of the ore, resulting in a greater production of concentrates, the extraction in 1914 was 1.46 per cent lower than in 1913. The use of the Belmont type steel liner for tube-mills has shown increased efficiency, and is expected to cut lining cost from \$0.032 per ton for silex to about \$0.0158. At the company's Millers plant the metallurgical process was changed from filtration to continuous decantation at a cost of \$24,930 for reconstruction. The mill treated 44,692 dry tons of ore at a profit of \$24,344, producing 1,031,745 oz. silver and 12,469 oz. gold. Before adopting the change in treatment the extraction averaged 87.45 per cent and the total milling cost was \$4.034 per ton. In January, 1915, after the change had been made, the extraction was 90.05 per cent and the cost \$3.766 per ton.

The **Montana-Tonopah Mines Company** milled during 1914 a total of 63,754 tons of ore of average value of \$8.991 per ton. The mill was closed from Nov. 15 to Dec. 31, 1914, on account of the lower grade of ore and low price for silver. The following table gives detailed milling costs:

Account	Labor Cost Per Ton	Supplies Cost Per Ton	Power Cost Per Ton	Total Cost Per Ton
Crushing and conveying....	\$0.079	\$0.021	\$0.019	\$0.119
Stamping .....	.074	.054	.147	.275
Elevating and separating....	.036	.011	.031	.078
Tube milling .....	.039	.103	.138	.280
Concentrating .....	.043	.006	.007	.056
Settling .....	.026	.065	...	.091
Agitating .....	.129	.539	.104	.772
Filtering and discharging....	.087	.053	.081	.221
Precipitating .....	.039	.076	.029	.144
Refining .....	.028	.043	...	.071
Water pumping .....	.026	.063	.013	.102
Steam heating .....	.060	.183	...	.243
Mechanical department ....	.027	.002	...	.029
Water .....	...	.245	...	.245
Assaying .....	.016	.002	...	.018
Superintendence .....	.050	...	...	.050
<b>Total .....</b>	<b>\$0.759</b>	<b>\$1.406</b>	<b>\$0.569</b>	<b>\$2.734</b>

The extraction by concentration was 31.2 per cent for gold and 17.8 per cent for silver; by cyanidation, 64.5 per cent for gold and 74.4 per cent for silver; total, 95.7 per cent for gold and 92.2 per cent for silver. Cyanide consumption was 2.08 lb. per ton milled, as against 3.22 lb. per ton in the preceding year. An improvement in filtering slime was made by the adoption of the Osgood filter, designed by Mr. C. G. Osgood, mill superintendent.

### The Iron and Steel Market

The situation in the iron industry as a whole is a difficult one to analyze. The steel trade proper shows continued improvement. Although production and shipments of steel products have been heavier in June than in May, the shipping orders received are stated to be in excess of shipments, and with much railroad material under contract but not yet the subject of actual specifications, steel mill operations promise to be still heavier in July, probably at the best rate since 1913. Steel prices, while not sharply advancing, are showing a stiffening tendency, and judging by conditions in their own trade steel makers feel that by August, or September at the latest, the steel mills will be operating at capacity, deliveries will be falling behind and prices will be on a firm basis at above to-day's level.

In striking contrast with this situation in the steel market proper is the fact that three important markets in the general iron situation, scrap, coke and pig iron, are dull and relatively soft. There is no distinct movement in any of them, and prices obtainable are not a particle higher than in December or January. Production and shipments of Connellsville coke are running at 330,000 tons a week, against 200,000 tons a week in December, an increase of 65 per cent, but \$1.50 has lately been done for spot coke and a trifle under \$1.70 for second half, prices that are if anything lower than what was obtainable in December or January. For two months scrap has been less active than in January, and prices are a shade lower. In pig iron there has been only a moderate volume of business, and indications now are that buyers are covered practically to the end of the year.

The dullness and softness in coke can be attributed to the dullness and softness in pig iron. That eliminates one unknown quantity, but still leaves two unknown quantities with only one equation from which to evaluate them. The only explanation that suggests itself is that since activity in the foundry trade, resulting in activity in pig iron, usually follows an improvement in steel by an interval of no more than a few months, and has now failed when six months or more have elapsed, and since the demand for direct export material and for material for war munitions to be made in this country involves steel rather than iron, the present condition in steel is that the activity is due chiefly to direct export and war demand, affecting steel but not pig iron. This may solve pig iron, but it does not solve scrap.

Intense activity in steel, however, is bound to affect pig iron, by creating a demand for merchant iron on the part of large steel works that are adequately fixed with blast furnace capacity for ordinary requirements, but have additional iron if their mills are to operate at an overload. The steel industry might then absorb enough extra Bessemer and basic iron to make up for the dullness in foundry grades.

Steel mill operations at the close of June are estimated at fully 80 per cent of rated capacity. The Pittsburgh district is operating at more than 80 per cent, while the Chicago, southern and eastern districts, are with a few exceptions, operating at less than 80 per cent. Here



and there mills are beginning to fall behind in deliveries, particularly in merchant bars. Predictions are made that operations will continue to increase, and if they increase much more the delay in deliveries will undoubtedly bring out a latent demand, as it always does, from jobbers and manufacturing consumers, who will see the desirability of laying in stocks to make certain of maintaining their normal operations.

At what rate the steel industry really can operate is an open question. Usually it has been able, upon occasion, to operate at an overload. At present there is some doubt whether the labor supply would admit of operating at ordinary capacity.

### Pig Iron

Recent developments suggest that the pig iron market has not as strong a foundation as was assumed. The buying of the past couple months has been better than in immediately preceding months, but a survey of the whole situation indicates that the ordinary buyers, the regular consumers, are fairly well covered practically to the end of the year, while a great deal of speculative iron has been bought, and some large consuming interests are known to have large stocks. One consumer of forge and foundry grades is credited with 100,000 tons lying at its various plants. The furnaces in operation may be fairly well sold up. It may even be granted that they are fully sold up to the end of the year, still justifying the observation that the furnaces operating represent no more than about 60 per cent of the merchant capacity, and raising the question, whence is demand to arise to improve the market? We quote No. 2 foundry, delivered Philadelphia, \$14.25 to \$14.50; f.o.b. furnace, Buffalo, \$12.50 to \$13; delivered Cleveland, \$13.25; f.o.b. furnace, Chicago, \$13 to \$13.25; f.o.b. Birmingham, prompt, \$9.50; third quarter and second half, \$9.75; at valley furnaces, 95c. higher delivered Pittsburgh; Bessemer, \$13.75; basic, \$12.65 to \$12.75; No. 2 foundry, \$12.75 to \$13; gray forge, \$12.50; malleable, \$12.75.

### Steel

Consumers are well covered for billets and sheet bars and the regular market is quiet, but with a very decided undertone of strength. The Carnegie Steel Company recently withdrew from the domestic market, and several recent export orders taken by the Steel Corporation have been placed at Chicago and Birmingham mills instead of the Carnegie mills at Pittsburgh. It is even reported that the Carnegie Steel Company has been a buyer of steel from other mills to apply on its contracts. We quote billets at \$19.50 to \$20 and sheet bars at \$20 to \$20.50, f.o.b. maker's mill, Youngstown, and 50c. to \$1 higher delivered Pittsburgh, the lower quotations referring to prompt shipment and the higher to shipment over third quarter. Rods are \$25, Pittsburgh.

### Finished Steel

Prior to the middle of June the large mills were all quoting 1.20c. on bars, plates and shapes for prompt shipment and 1.25c. on contracts for third quarter, while several small plate mills were quoting 1.15c. and less on plates. On June 14 the Carnegie Steel Company withdrew its lower price entirely and since then the other large mills have been gradually working up to the higher level, while the small plate mills have firmed up to 1.15c. as minimum. Indications are that bars and shapes will be firm at 1.25c. for third quarter and 1.30c. for fourth quarter, while plates may work up to 1.20c. or possibly 1.25c., depending largely upon railroad buying of cars. June 15 steel boiler tubes were advanced one point or about \$2 a ton. June

1 galvanized steel pipe was advanced five points and June 17 six points more, a point being nominally 95c. per net ton. Galvanized sheets have worked up to a minimum of 5.00c., with as high as 6.00c. sometimes quoted, while there are few sellers. The differential on galvanized wire, formerly 40c. per 100 lb., has advanced at various times this year until it is now 80c., with mills usually limiting the tonnage they will accept. These advances were occasioned by the flight of spelter, to 26c. to 27c. on June 4, and are based upon a spelter cost somewhat exceeding 20c., but after the high point was reached June 4, spelter began declining and crossed 20c. on June 17. Whether it will eventually find a level above or below 20c. no one ventures to guess.

Current quotations are as follows for ordinary deliveries, f.o.b. Pittsburgh, unless otherwise noted:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.15c. to 1.25c.

Shapes, 1.25c.

Steel bars and bands, 1.25c., base; hoops, 1.25c. to 1.30c., base.

Iron bars, 1.20c. to 1.25c. Pittsburgh; 1.17½c. to 1.22½c., Philadelphia; 1.15c. to 1.20c. Chicago.

Sheets, blue annealed, 10-gage, 1.35c.; black, 28-gage, 1.75c.; galvanized, 28-gage, 5.00c. to 5.50c.; painted corrugated, 28-gage, 1.95c.; galvanized corrugated, 28-gage, 5.05c. to 5.55c.

Tin plate, \$3.10 to \$3.20 for 100-lb. coke.

Steel pipe, ¾ to 3-in., black, 79 per cent off list; galvanized, 57½ per cent off list.

Steel boiler tubes (less than carloads), 3½ to 4½ in., 73 per cent off list.

Structural rivets, 1.50c.; boiler rivets, 1.60c.

## The Western Trip and the Los Angeles and San Francisco Meetings of the American Institute of Chemical Engineers

The party of the American Institute of Chemical Engineers will leave New York on Friday, Aug. 6, via Pennsylvania Railroad at 5.04 p. m.; leave Chicago on Saturday, Aug. 7, via Santa Fé, and arrive on Monday, Aug. 9, 7 a. m., at Colorado Springs, where Monday and Tuesday will be spent (trips to Cripple Creek, Pike's Peak, etc.). The party leaves Colorado Springs on Tuesday, 6.45 p. m., and arrives at the Grand Canyon on Thursday 1.50 a. m. Thursday will be spent in sight-seeing in the canyon. The train leaves Grand Canyon Thursday, 8 p. m., and arrives in San Diego on Friday, Aug. 13, 6 p. m. Saturday and Sunday will be spent in San Diego in visiting the exposition. The party leaves San Diego Sunday, 11.59 p. m., and arrives at Los Angeles on Monday, Aug. 16, 3.30 a. m.

### LOS ANGELES MEETING

Monday, Tuesday and Wednesday, Aug. 16, 17, 18, will be spent in Los Angeles. For Monday a trip to Redondo Beach (oil-burning power plant), San Pedro Harbor (salt plant and kelp industry), Long Beach, Huntington Beach (beet sugar factory) and Santa Ana has been arranged, for Tuesday a trip to Catalina Islands. Monday evening the mission play at Alhambra will be visited. Various optional trips have been arranged for Wednesday, while on Wednesday evening a joint meeting will be held with the Southern California section of the American Chemical Society.

On Thursday, Aug. 19, 7.25 a. m., the party will leave Los Angeles for San Francisco. Stops will be made at Santa Barbara (or Oxnard beet sugar factory) and Del Monte and the Yosemite Valley may be visited for three days.



## SAN FRANCISCO MEETING

Wednesday to Saturday, Aug. 25 to 28, will be devoted to the meeting at San Francisco. On Wednesday afternoon an excursion will be made to the Protrero oil gas works, on Saturday an excursion to the Winehaven vineyard and wineries. The program of the technical sessions is as follows:

*Wednesday*, Aug. 25, 11 a. m., at Civic Center Auditorium, San Francisco:

A. M. McAfee—"The Improvement of High Boiling Petroleum Oils and the Manufacture of Gasoline as a Byproduct Therefrom by the Action of Aluminium Chloride."

Arthur L. Lachman—"Wine Making."

*Thursday*, Aug. 26, 10 a. m., at University of California, Berkeley:

Ralph A. Gould—"Costs as Applied to Professional Businesses."

Edgar Baruch—"Resources and Possibilities of the Chemical Industry in the Southwest."

Otto Best—"Manufacture of Cream of Tartar."

*Friday*, Aug. 27, 10.15 a. m., at Leland Stanford University, Palo Alto:

S. W. Young—"Present State of the Thiogen Industry."

Edward Bartow—"Purification of Sewage by Aeration in Presence of Activated Sludge."

Walter A. Schmidt—"Electrical Precipitation Method."

Members of the party will have the option of going from San Francisco to Seattle either by rail or partly by steamer to attend the Seattle meeting of the American Chemical Society for one day, on Thursday, September 2. On the evening of the same day the party will start on the return trip, which includes a stop at Butte and Anaconda (Saturday and Sunday, Sept. 4 and 5), and a visit to Yellowstone Park (Monday to Saturday, Sept. 6 to 11).

The party will leave Yellowstone Park at Gardiner on Saturday, Sept. 11, 7.15 p.m., and is due in New York on Sunday, Sept. 19, 7.57 a.m.

Dr. John C. Olsen, Cooper Union, New York City, is the secretary of the Institute.

### The Western Trip of the American Chemical Society

As has already been announced, the autumn meeting of the American Chemical Society will be held in Seattle, Washington, from August 31 to September 2.

The following trip by special train has been arranged to take the Eastern members to Seattle:

The train leaves *Chicago* on Thursday, August 26, at 5:05 p. m., via Chicago & Northwestern Railway, arriving at St. Paul, Minn., on August 27, at 5 a. m., and leaving 30 minutes later via Great Northern Railway. It passes through the scenic lake park country of Northern Minnesota and the immense grain fields of North Dakota and Eastern Montana.

Glacier Park Station is reached on Saturday, August 28, at 2 p. m., and Saturday afternoon and Sunday are spent in the *Glacier National Park* (automobile trip on Saturday afternoon through the Two Medicine and Cut Bank Valleys to the St. Mary Camp and launch ride on the Lake St. Mary. The night is spent at the Going-to-the-Sun Camp. On Sunday return launch ride to St. Mary Camp and automobile trip through the Sherbourne Lake country to Many Glacier Camp.)

The train leaves Glacier Park Station on Sunday afternoon (August 29) and arrives in *Seattle* on Monday afternoon, 6 p. m. Tuesday, Wednesday, and Thursday (August 31 to September 2) are spent in Seattle attending the American Chemical Society meeting.

Seattle is left on the evening of Thursday, September 2, at 11:55 p. m. The train arrives on Friday, September 3, at 4:35 a. m., at Ashford, from where the trip to the *Mount Rainier Park* is made. From the National Park Inn at Mount Rainier several side trips may be made during the day.

The train leaves Ashford the same afternoon at 4:35 and arrives in *Portland* on September 4, at 6 a. m. The whole of Saturday is allowed for sightseeing in Portland. The train leaves Portland 8:15 p. m. and is due in *San Francisco* on Sunday evening, September 5.

It is of the utmost importance for the success of this trip that the Secretary of the American Chemical Society, Dr. Charles L. Parsons, Box 505, Washington, D. C., be informed as soon as possible by those members who want to join in the trip.

### Special Trains of Civil, Mining, Mechanical, and Electrical Engineers to International Engineering Congress

Two special trains have been arranged jointly by the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, in connection with the International Engineering Congress.

The first train will leave New York (Grand Central Terminal) on Thursday, September 9, at 7.45 p. m. and arrive at San Francisco on Wednesday, September 15, at 9 p. m. A 4-hour stop will be made at Niagara Falls (Sept. 10), a 12-hour stop at Colorado Springs (Sept. 12), and a 15-hour stop at the Grand Canyon, Arizona (Sept. 14).

The second train—or at least a number of special cars on the *Sunset Limited*—will leave New Orleans on Sunday, September 12, 11 a. m., and arrive at San Francisco on Wednesday, September 15, 1 p. m.

Members of the societies of Civil, Mining, Mechanical, Electrical Engineers and Naval Architects, whether members of the Congress or not, and members of the Congress, whether members of any of those five societies or not, will be welcome to join these special trains. Mr. Charles Warren Hunt, 220 West 57th Street, New York City, is the secretary of the joint committee on reception and transportation.

### The Western Trip of the American Electrochemical Society

The Fall meeting of the American Electrochemical Society will be held in San Francisco on Thursday, Friday and Saturday, September 16, 17, 18, 1915; that is on the same dates as the meetings of the civil, electrical, mechanical, and mining engineers, and at the close of the week, immediately preceding the International Engineering Congress. Arrangements have already been made for joint sessions with the Electrical Engineers and the Mining Engineers.

Mr. J. M. Muir, 239 W. 39th Street, New York City, has been appointed chairman of the transportation committee. It is the intention to arrange a number of special cars for members and friends of the American Electrochemical Society, to go by as cool a route as possible directly to San Francisco, to arrive there on Wednesday, September 15. The return trip may be made as desired, and the stops for sight-seeing would be made on the return trip.

To those members of the American Electrochemical Society who want to include sight-seeing stops in the outgoing trip, two opportunities are afforded.

The American Chemical Society has extended a cordial invitation to members of the American Electro-

chemical Society to join in the special train which carries the former society to its meeting in Seattle. (See program, page 419.)

The special train of the four engineering societies for San Francisco may be used by those who are either members of the Mining or Electrical or Mechanical or Civil Engineers, or are members of the International Engineering Congress. (See itinerary, page 419.)

### The Corrosion Problem Before the American Iron and Steel Institute

The meeting of the American Iron and Steel Institute, held in the Hotel Waldorf in New York on Friday, May 28, 1915, brought out quite a number of able and interesting papers, on "Blast Furnace Advancement," by Andrew E. Maccoun, on "Merchant Rolling Mills" by Jerome R. George, on "The Commercial Production of Sound and Homogeneous Steel" by Edward F. Kenney, on "Wash Boiler Heaters" by Charles J. Bacon, and on "Recent Progress in Corrosion Resistance" by Daniel M. Buck. The last paper elicited a long discussion.

Mr. Daniel M. Buck, who is metallurgical engineer of the American Sheet & Tin Plate Company, reported on several years' exposure tests of full-sized sheets, unprotected in any way, under service conditions.

"The influence on corrosion of carbon, manganese, phosphorus, and silicon in the amounts normally present in properly made steels and irons is practically negligible. In a steel without copper, high sulphur content stimulates corrosion. A copper content of 0.25 per cent materially increases the life of steel and iron, and the harmful effect of sulphur up to at least 0.14 per cent is neutralized by 0.25 per cent copper. More copper, up to 2 per cent, gives little, if any, additional benefit. Lesser amounts than 0.25 per cent have great influence in lowering the corrosion rate. A content of 0.15 per cent is in most cases quite as good as 0.25 per cent, and tests now under way prove that much lower amounts, down to as little as 0.04 per cent and 0.06 per cent, while not giving the best results, are superior to normal steels carrying only the usual traces of copper."

Dr. Allerton S. Cushman, director of the Institute of Industrial Research, Washington, D. C., opened the discussion, representing the opposite side. In his opinion "Mr. Buck's tests on which he bases his conclusions are open to criticism both in their conduct as well as in the interpretation of the results obtained."

"Mr. Buck in his paper sounds the warning that the benefits he claims accrue only if the copper is properly added to molten steel. About 0.2 per cent of benzoate of soda has been used to preserve and make salable very bad tomato catsup, but its presence cannot turn bad and dirty stuff into good and clean food. In my opinion, precisely the same thing is true of 0.2 per cent of copper in steel."

"At my original suggestion, the corrosion committee of the American Society for Testing Materials is about to undertake a series of systematic weather exposure tests on large corrugated sheets of 16 and 22-gauge iron and steel of all types now available in the open market. These sheets are not to be pickled and only a portion of the heavier gauge are to be sand-blasted. Until these authoritative and unbiased tests can be reported on, it is my belief that such sweeping claims as Mr. Buck has made in his paper are quite unjustified. My own opinion, based on what I consider the most reliable data yet available, is that in metals, as in food, purity is the safest criterion of excellence."

Mr. James O. Handy, director of the chemical laboratories of the Pittsburgh Testing Laboratory, sustained the exactness of Mr. Buck's tests.

"We feel certain that in some way the accelerating

effect upon corrosion exercised by sulphur in steel is entirely inhibited by the addition of copper. The most probable theory is that copper unites with the sulphur and the copper sulphide dissolves in the excess copper, and the mixture dissolves in the steel itself. The sulphide of copper is not as readily oxidized as sulphide of iron or sulphide of manganese, and copper itself is extremely weather resistant. The steel, therefore, is far less readily oxidized than when the sulphides of iron or manganese are present in the steel."

"The critical percentage at which copper begins to control the corrosion of steel is between 0.03 per cent and 0.04 per cent. The difference is very striking. The corrosion rate is 100 per cent higher in the case of steels or irons containing less than 0.03 per cent copper, as compared with those containing over 0.04 per cent."

Dr. Wm. H. Walker, professor of chemical engineering of the Massachusetts Institute of Technology, emphasized that according to the electrolytic corrosion theory metal plus water yields metal hydroxide plus hydrogen; there are therefore four factors to be considered, and some adherents of the electrolytic theory err in considering only the effect of the metal and neglecting the effect of the other factors, the hydroxide and the hydrogen. A complete theory should pay attention to the influence which the other ingredients—not iron—may have on the solution pressure of the iron or upon the depolarization of the hydrogen or on the character of the iron hydroxide formed. His own experiments substantiate Buck's results. He has found that the film of iron hydroxide or rust which forms on a surface of copper steel is much denser and depolarizes much more slowly than does that on any other type of iron or steel.

Dr. John S. Unger, metallurgist of the Carnegie Steel Company, confirmed Mr. Buck's results on the beneficial effect of copper in steel. He believed that Mr. Buck's exposure tests were imitations of the conditions in actual practice, as far as this is possible.

Mr. G. H. Charls, vice-president of the American Rolling Mill Company of Middletown, Ohio, said it was "indeed very gratifying to observe that Mr. Buck has proved so conclusively in his table that No. 27-gauge pure iron has at least twice the life of steel. No one can justly accuse the author of this paper of being an ardent advocate of pure iron. This truth becomes more remarkable when you are informed that 27-gauge black pure iron is not even advocated by its producers because it cannot always be rolled satisfactorily. This is explained by the fact that pure iron is so soft, so ductile and welds so readily that the 27-gauge sheets stick fast together in rolling and are often damaged when torn apart."

"Due to the courtesy of Mr. Buck, a sheet taken from this lot which was to be tested came under my observation. In measuring the thickness of this sheet, it proved to be nearer 28 gauge than 27 gauge in many places, due to the difficulty of obtaining a uniform gauge in rolling such light material. It is therefore doubly gratifying to note the splendid record made by this light weight 27-gauge pure iron, pickled before it was tested to almost a tissue paper thickness, made under protest and against the advice of its producers and in every way unworthy of being considered a representative product by any fair-minded person."

"If under such adverse conditions pure iron outlasts steel two to one, it must be conceded that the claims made for this product have been thoroughly substantiated and sustained. This would be very welcome information to the thousands of purchasers of pure iron if they were not already aware of the intrinsic value of this product and its superiority to steel from the standpoint of resistance to corrosion."



## Cyanidation of Low-Grade Sulphide Ores in Colorado—I

BY H. C. PARMELEE

### Clear Creek and Gilpin Counties

On the eastern slope of the Rocky Mountains in Colorado, Clear Creek, Gilpin and Boulder form a trio of contiguous counties in which the earliest mining operations in the State began. Profitable mining and metallurgical treatment in this mineral empire date back to 1859. Since that time production has been continuous, with varying fortunes to individual operators, but on the whole successful and with great credit to the several districts and to the State. In general, the metallurgical treatment of the ores has followed the practice first established, amalgamation and concentration, or smelting. The milling practice has been the subject of unfavorable criticism, some of it warranted but much of it superficial and without a full knowledge of the economic conditions. Undoubtedly the metallurgical losses in concentration have been large; but the flotation process which is now being applied at some of the oldest mills should make possible an additional economic recovery of minerals hitherto lost.

Proposals to introduce modern cyanide practice in Gilpin and Clear Creek counties have been made periodically for the past five years. In 1911 Draper and Gross made exhaustive experiments on Gilpin county ores, the results of which indicated the possibility of successful cyanidation. In 1912 the Hudson mill at Idaho Springs added cyanidation to amalgamation and concentration. Little or no metallurgical difficulty was encountered, but for economic reasons cyanidation was abandoned. The practice was described in this journal at the time the mill was in operation.<sup>1</sup> In 1913 the Argo mill was constructed, and a treatment process adopted similar to that used at the Hudson. After a few months' operation, however, this plant also was closed, and it appeared as though it were impossible to apply the cyanide process profitably to Clear Creek and Gilpin ores. Nevertheless, the mill was started again under new and competent management and has been in continuous operation for eighteen months, demonstrating the metallurgical and economic success of cyanidation in this district.

### Difficult Problems at the Argo Mill

It would be difficult to imagine more exacting and trying metallurgical conditions than those existing at the Argo mill. The mill is operated on a custom basis, sampling and buying ores as offered. There are no ore contracts, which would be of little value if they existed, for the ore supply comes mainly from leasers whose operations are irregular. Shipments are received in small lots ranging from 5 to 75 tons each, and averaging perhaps 15 or 29 tons. Frequently these lots are sampled and actually milled before assays can be made to determine their value. One lot may be of value mainly for its gold content, while the next is rich in silver. The ratios of concentration of successive lots may range from 2:1 to 25 or 30:1. Ores producing slime of fair settling rate follow those that are exceedingly difficult to settle, while the values of successive lots may range from \$3 to \$50 or more per ton. The sand tailings from some of the ores could be discarded without economic waste, and thus avoid the cost of regrinding; but in other instances the value of the sand necessitates regrinding in order to make an economic recovery.

Coupling these conditions with irregular and unex-

pected deliveries of ore, the necessity of satisfying the shipper by immediate sampling and settlement, and the impracticability of bedding ores in order to secure uniformity in mill feed, we find about as unfavorable conditions for cyanidation as could be imagined. Such conditions as these are unknown at a mill serving a single mine, where reasonable uniformity in quantity, quality and value of the ore can be expected, and where conditions of treatment can be determined and fixed by preliminary tests.

Preliminary testing at Argo has proved futile, for by the time the metallurgist may have discovered and solved a problem presented by a certain ore, production of that ore may cease. In view of these facts it is not surprising that the details of milling have undergone decided changes since operations first began, and even within the history of the present management. Hence, previously published accounts of the practice<sup>2</sup> do not adequately represent present operations.

### Location and Construction

The Argo mill, shown in Fig. 1, is situated near the mouth of the Argo tunnel, from which the greater part of the ore supply comes. While the location is con-

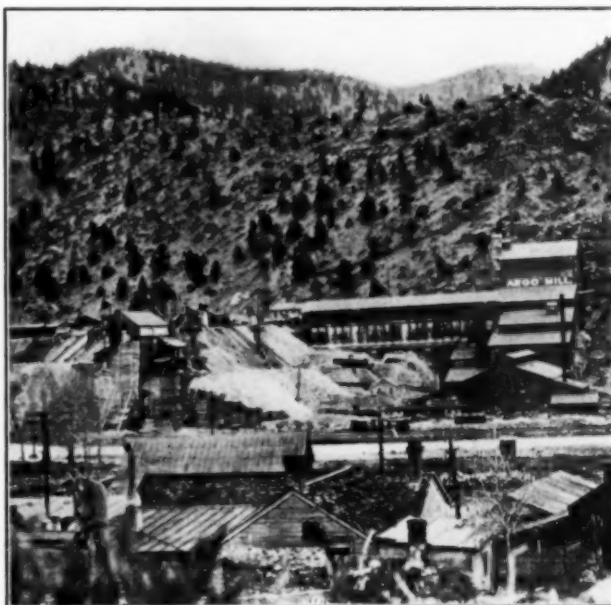


FIG. 1—THE ARGO MILL

venient with regard to delivery of ore, disadvantages have developed from the erection of the mill on a waste dump. In some parts the original excavation was not deep enough to insure solid foundations, with the result that subsequent settling dislocated part of the equipment, entailing additional expense and loss of time. Another difficulty developed due to uneven surfacing of the concrete mortar blocks, making it impossible to secure the mortars firmly on their foundations. This was overcome by loosening the bolts and calking the seams with oakum, after which the mortars could be held firmly on their foundations.

These troubles have now been largely overcome, and in all recent work special precautions have been taken to secure solid footings. The foundation for a tube-mill recently installed is a solid concrete monolith, reinforced with steel rails with the ends bent upward into the piers which support the bearings. The mill building is of modern steel construction with concrete

<sup>1</sup>Cyaniding by Continuous Decantation in Clear Creek County, Colorado. H. C. Parmelee. This Journal, Jan., 1912, p. 27.

<sup>2</sup>Ore Treatment at the Argo Mill. A. H. Roller and H. T. Curran. Eng. & Min. Jnl., July 4, 1914. Cyanidation of Clear Creek and Gilpin County Sulphides. J. A. Pearce. Min. & Sci. Press, Nov. 28, 1914.

foundations and floors. Argon-filled tungsten lamps are used for artificial lighting and give excellent satisfaction.

### Coarse Crushing and Sampling

An accurate sampling plant is necessary in order to evaluate properly the numerous lots of ore purchased. Ore is delivered in 3-ton cars, three of which can be accommodated in a revolvable tippie that traverses tracks above a series of twenty-two individual storage bins. When a shipment is completed the ore is drawn from the bin onto a pan conveyor running the full length of the bin house, and delivered to the sampling plant. The latter is of approved modern type, in which a fraction of the lot is successively crushed and split until a suitable sample is obtained. The reject passes to an elevator and is delivered directly to the battery bins by

remove the sulphides unlocked in regrinding; thickening, filtration and precipitation.

The stamps are of 1050-lb. weight, dropping 108 times per minute through a height of 6 in. A heavy stamp is not required to crush those ores from which the coarse-grained sulphides are readily unlocked for concentration, while tube-milling is essential to release the minerals from the harder silicified ores. Stamp shoes and dies are of chrome steel, and the latter are sectionalized for the purpose of reducing the consumption of metal represented in discarded parts. The upper portion of the die is wedged into the lower, care being taken to get it in place evenly so that a horizontal wearing surface will be presented to the shoe. A brief experience with these sectionalized dies indicates that the upper section can be worn very thin before it is discarded. Ton-cap screens equivalent to sixteen-mesh are used on the batteries, and in crushing to this size the twenty stamps have a capacity of 120 tons per day.

The ore is crushed in cyanide solution, and the battery discharge is classified into sand and slime in a Dorr duplex classifier. The sand is treated without further classification on card tables, producing lead and iron concentrates and sand tailing. This primary concentration removes the major portion of the gold-bearing sulphides from the pulp. A secondary concentration of the slime after regrinding and agitation completes the separation of sulphides as gravity concentration can do so.

### Protection of Table Decks

For the protection and preservation of the linoleum decks on the concentrating tables, a satisfactory material has been found in P & B paint diluted one-half with carbon disulphide. The paint can be used at normal consistency, but comparative tests at this mill have shown that it does not penetrate the linoleum as well as when diluted. The paint is applied hot and forms more than a mere superficial coating on the linoleum.

The lead and iron concentrates are finished products, and are dewatered, stored in bins and shipped to the smelter. The separation of the two concentrates on the tables is made with reference to their relative gold contents rather than to that of the base metals, and is governed wholly by economic considerations. The most favorable smelter rates apply to a 5-oz. gold concentrate, for which payment is made at the rate of \$20 per ounce of gold. At the same time it is desirable to keep the grade of above 5 per cent lead if the most favorable treatment charge is to be obtained. Hence enough pyrite is cut into the galena to produce these conditions in the lead concentrate, and the balance is recovered as an iron concentrate carrying about 1 oz. gold per ton.

### All-Sliming Following Concentration

Several methods have been in effect for the treatment following primary concentration. Originally the sand tailing was discharged as waste, being first washed with barren solution and water, and finally dewatered, in a Dorr three-deck classifier. While this practice was suitable to ores which yielded readily to concentration after coarse crushing, it was untenable with others on account of the high gold loss sustained in the finely disseminated sulphides that were not unlocked in stamping. Later a double flow-sheet was adopted, in which sand tailing from ores of the first class was washed, dewatered and discharged, while middling from the second class was reground in a tube-mill. Finally the practice was adopted of sliming all sand tailing from primary concentration, and for this purpose a new tube-mill, 5 ft. by 16 ft., was added.

The tube-mill is in closed circuit with a second Dorr duplex classifier. El Oro lining is used and the grinders

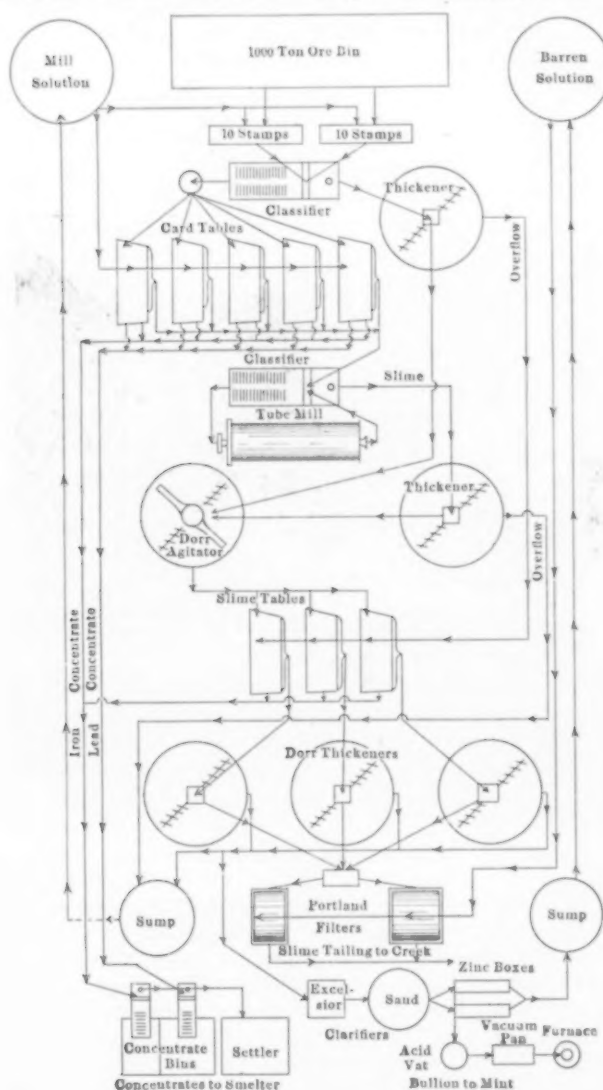


FIG. 2—FLOW-SHEET ARGO MILL

means of a conveyor and traveling tripper. This relation of the sampling plant to the mill explains why it is necessary to treat the ore as it comes, as well as the possibility of completing the treatment of a small lot before its value is known.

### Flow-Sheet

The flow of the ore through the mill is outlined in Fig. 2. Briefly, the process includes stamping in cyanide solution; primary concentration to remove lead, iron and copper sulphides; regrinding the sand tailing in a tube-mill; agitation; secondary concentration to



are imported Danish and French pebbles. Pebble consumption is 3.5 lb. per ton when the plant is running at full capacity, but rises with decreased tonnage.

The slime leaving this second classifier is thickened and combined with a similar product from the first classifier, and subjected to agitation. Cyanide is added at the agitator. The agitation process is continuous in a single Dorr agitator. After agitation the pulp is again concentrated, the mineral product being combined with the primary iron concentrate. The wash water used on the secondary tables is the overflow from the primary thickener, and serves to wash and dilute the pulp flowing to the final thickeners.

#### Diaphragm Pumps for Pulp Transfer

The transfer of slime pulp from thickeners to agitator and filters is accomplished by diaphragm pumps. The general advantages of this type of pump for maintaining uniform conditions as to quantity and density of pulp transferred have become well known. Their



FIG. 3—DIAPHRAGM PUMP—OPEN

use in the cyanide process has led to the development of certain desirable features not usually found. An improved pump for this purpose, now in use at the Argo mill, is shown in Figs. 3 and 4, being the design of Mr. Henry Eggers of the Mine and Smelter Supply Company. It is adjustable, while running, from zero to full stroke, thus permitting an instant change in capacity without changing speed. The rocking motion usually imparted to diaphragms, and which is so destructive to long service, is eliminated by applying a vertical stroke to the diaphragm. Plunger guides and other moving parts are protected against undue wear from grit and slime. Suction may be applied from either side or from the bottom. For convenience in changing diaphragms the upper portion of the pump is hinged to the lower and can be thrown back after loosening the eye-bolts.

#### Filtration of Slime

The slime tailing from secondary concentration flows to three Dorr thickeners operated in parallel. The overflowing solution is clarified and precipitated, and the thickened underflow is filtered on Portland revolving

filters. Filtration was not a part of the original mill scheme, but was added by the present management after long and careful tests on the feasibility of treating these ores by continuous counter-current decantation as first attempted. As a class, the ores produce a slow-settling slime, rendering continuous decantation difficult in most cases and impossible in others, assuming a reasonable settling area per ton of material treated. This gave rise to muddy overflows and dilute underflows from the thickeners even when operated at much less than normal capacity. Considering the lack of uniformity in mill feed it is not surprising that a process which has proved so successful in many instances was not feasible here. The experience probably would have been avoided by more careful preliminary tests.

The filters give excellent satisfaction, successive washes of barren solution and water reducing the loss of dissolved gold to a negligible quantity. A vacuum of 18 or 19 in. is maintained. Little trouble is experienced in keeping the filter fabric clean and porous. Instead of giving the entire filter an acid wash at long intervals,

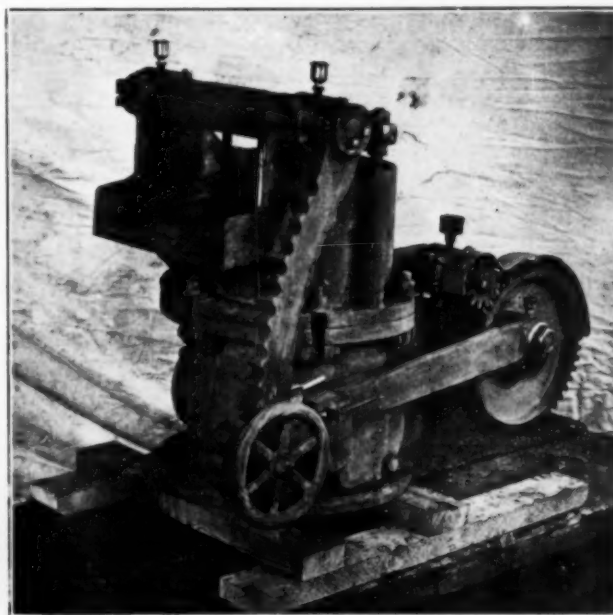


FIG. 4—DIAPHRAGM PUMP—CLOSED

one or two sections are treated daily with a dilute solution of hydrochloric acid, scrubbing the fabric with whiskbrooms. This method avoids the necessity of periodically removing the slime from the filter tank in order to give the entire filter an acid bath. It also eliminates acid-storage tanks and means for transferring acid solutions.

The quantity of circulating mill solution is kept constant by the addition of the requisite amount of water in the final wash on the filter.

#### Clarifying Solutions Before Precipitation

The marked effect of clear solutions on the efficiency of precipitation has been well exemplified at this mill. Since adopting adequate means for clarifying the pregnant solution, the earlier difficulties in precipitation have been entirely overcome. The solution flowing from the three final Dorr thickeners is passed successively through excelsior and sand clarifiers. The former consists of about 750 cu. ft. of excelsior packed in a rectangular tank having a false bottom. The solution is introduced beneath the excelsior and flows upward. The excelsior is cleaned about once in two months and re-

packed. The sand filter is about 4 ft. deep, being deeper than is usual for such purposes. Every four to six weeks a 6-in. layer of sand is removed, thoroughly washed and replaced. Previous to the adoption of these methods considerable difficulty was experienced in precipitation, chiefly in the efficiency of the operation and the grade of precipitate produced. The latter has been raised from as low as \$1.50 to \$40 per pound. The value of the zinc-box head solution is about \$1 per ton. The tail solution has a value of about ten cents per ton.

The solution is precipitated on zinc shavings in two three-compartment boxes. No lead acetate is used, neither is any lead shaving added to the zinc. The rate of precipitation is about two tons of solution per ton of ore, when running at full mill capacity. In making the clean-up the work is done as rapidly as possible to avoid long exposure of the zinc to air. No attempt is made to effect a complete clean-up of the precious metals, as it has been found favorable to good precipitation to leave some gold on the zinc. On account of the appreciable quantities of copper in some of the ores the solution contains about 0.03 per cent copper, and this tends to lower the grade of the bullion. Until recently the bullion marketed has contained from 15 per cent to 25 per cent copper, but this has been reduced to about 1 per cent as the result of a refining process evolved by Mr. Jackson A. Pearce, metallurgist for the company. For sufficient reasons the details of the method have not yet been made public, but the benefits are very apparent.

#### Warm Solutions Aid Extraction

Gold and silver are the metals of principal value in the ores treated. In general, it may be said that 40 per cent of the silver in the ores is not amenable to cyanidation, but a good recovery is made by concentration. Altogether an average extraction is made of slightly over 90 per cent of the value of the gold and silver. Some lead is recovered, but there is no attempt to save zinc, nor to make an economic recovery of copper. Both of the latter metals enter into the iron concentrate.

It has been found advantageous to warm the pulp and solution to a temperature of from 60 to 65 deg. F., by means of steam coils and live steam in the thickeners. This temperature has been found to give the maximum benefit with the minimum disadvantage. It will be apparent that, with the variety of ores treated, the effect of temperature is likely to be quite as various. While extraction of silver can be increased at a higher temperature and with stronger solution, the consumption of cyanide by cupriferous ores becomes excessive. Also, the settlement of slime is variously affected by changes in temperature, being improved in the case of some ores and unfavorably affected in others.

The value of the mill feed will range from \$5 to \$20 per ton; and of the tailing, from \$0.85 to \$1. The solution in the agitator is kept at a strength of 1.7 lb. KCN per ton, with 0.8 lb. CaO.

The tonnage treated is determined by intercepting the flow of slime pulp to the filters, allowing the full stream to run into a calibrated tank for a definite time and noting the volume. Before settlement can occur, a definite volume is removed, dried and weighed, and the calculation made. This method has been found quite accurate on thick pulps, though not so well adapted to thin ones. In this case the pulp flowing to the filters contains about 1½ parts solution to 1 of solids.

#### Power Requirements

Electricity is the motive power used throughout the mill. A list of the motors, the machinery driven by them, and recent tests of power consumption are given below. Back-gearred motors are used at the stamps.

Rated hp. of motor	Machinery driven	Horsepower consumed
25	Ten 1050-lb. stamps.....	22.5
50	One 5 ft. by 16 ft. tube-mill.....	60
5	Four diaphragm pumps, four 20 ft. by 12 ft. thickeners, one 20 ft. by 12 ft. agitator, two Portland filters, two quarter-size Dorr classifiers.....	2.7
5	Three Card tables, one 22 ft. by 14 ft. Dorr thickener, one duplex classifier.....	4.8
20	Two elevators, two conveyors and tripper.....	15
20	Two 12 by 10 vacuum pumps, one 5 by 8 and one 4 by 6 triplex pumps, one 1½ in. centrifugal pump.....	14
5	Two centrifugal pumps, three Card tables.....	4
25	In sampler. Fan conveyor, 4-k gyrotory crusher, small jaw crusher and three sets small rolls.....	22

#### Mill Records

A system of metallurgical records devised to meet the special and varied needs at the Argo mill afford complete information regarding all operations. These are segregated under three main headings: Daily mill sheet, record of ore purchased, and record of products sold. The record sheets are 32 in. by 15 in. in size, each page serving for a month's record. The sheets are too large for reproduction in exact form, but the data can be rearranged from the following tabulations:

#### DAILY MILL RECORD

RUNNING TIME	ASSAYS, TITRATIONS, SCREEN ANALYSES		SPECIFIC GRAVITY AND TEMPERATURE	
	Pulp		Tube-mill discharge	
Hours	Battery	Heads	Specific Gravity	
Stamps	Gold		Temperature °F.	
Tube-Mill	Silver		Agitator	
Cause of Delay	Total		Specific Gravity	
TONNAGES	Slime		Temperature °F.	
Solution	Gold		Mill	
Day	Silver		Temperature °F.	
Ore	Total		MATERIALS USED	
Day	—200		KCN	
To Date	Solution		CaO	
Slime	Zinc Box Heads		Pebbles	
Day	Gold		Zinc	
To Date	Silver		GROSS VALUES	
Concentrate	Total		Ore Milled	
To Date	KCN		Day	
	CaO		To Date	
	Zinc Box Tails		Solution Precipitated	
	Gold		Day	
	Silver		To Date	
	Total		Slime	
	Agitator		Day	
	KCN		To Date	
	CaO		REMARKS	

#### RECORD OF ORE PURCHASED

Car Number	Pounds Copper
Initial	Value Copper in Lot
Date Shipped	Percent Zinc
Shipper	Value Zinc per Ton
Mine	Pounds Zinc
Date Sampled	Value Zinc in Lot
Wet Tons	Settlement Value per Ton
Percent Moisture	Gross Value per Ton
Dry Tons	Gross Value Ore in Lot
Oz. Gold per Ton	Deduction Silver per Ton
Value Gold per Ton	Value Deduction Silver
Value Gold per Oz.	Treatment per Ton
Oz. Gold in Lot	Total Amount Treatment
Value Gold in Lot	Total Amount Paid for Lot
Oz. Silver per Ton	Settlement Value Ore in Lot
Value Silver per Ton	Freight Deducted
Value Silver per Oz.	Sampling Deducted
Oz. Silver in Lot	Umpire Charges
Value Silver in Lot	Net Proceeds
Percent Lead	Remarks
Value Lead per Ton	Royalty Received
Pounds Lead	Percent
Value Lead in Lot	Amount
Percent Copper	
Value Copper per Ton	

#### RECORD OF PRODUCTS SOLD

Car Number	Value Copper per Ton
Initial	Pounds Copper
Date Shipped	Value Copper in Lot
Shipped To	Percent Zinc
Class	Value Zinc per Ton
Date Sampled	Pounds Zinc
Wet Tons	Value Zinc in Lot
Percent Moisture	Settlement Value per Ton
Dry Tons	Gross Value per Ton
Oz. Gold per Ton	Gross Value Ore in Lot
Value Gold per Ton	Deduction Silver per Ton
Value Gold per Oz.	Value Deduction Silver
Oz. Gold in Lot	Treatment per Ton
Value Gold in Lot	Total Amount Treatment
Oz. Silver per Ton	Total Amount Paid for Lot
Value Silver per Ton	Settlement Value Ore in Lot
Value Silver per Oz.	Freight Deducted
Oz. Silver in Lot	Sampling Deducted
Value Silver in Lot	Umpire Charges
Percent Lead	Net Proceeds
Value Lead per Ton	Remarks
Pounds Lead	Royalty Received
Value Lead in Lot	Percent
Percent Copper	Amount



Tests conducted at the Argo mill indicate that the concentrates can be profitably cyanided, but at present the mill is not equipped for the work. The silver recovery probably would not exceed 60 per cent, but the gold extraction would be satisfactory. The value of the gold recovered as bullion would exceed its value in the form of concentrate, and the difference would be more than the cost of treatment. The residue from cyanide treatment would still form a low-grade shipping product, and would receive the most favorable treatment rate at the smelter. Balancing all the factors involved, the net result of cyaniding concentrates and shipping the residue to the smelter would show an increased profit as compared with the present practice of shipping direct.

The successful operation of a custom cyanide mill like the Argo depends on exhaustive preliminary tests, both chemical and physical; attention to numerous details; a careful balancing of causes and effects to secure the most economical average conditions, and last, but not least, an assured steady ore supply. The design of a new mill to meet the same conditions at Idaho Springs probably would not vary much from the present plan, which is the result of eighteen months' experience. It is likely that flotation would find a place in the flow-sheet, probably as the final step, concentrating the filter tailing. Secondary concentration after agitation could then be abandoned, and an economic advantage gained by leaving the slimed sulphides in the system to receive the maximum cyanide treatment, since gold in bullion is worth \$20.67 per ounce, but only \$19 per ounce in a low-grade concentrate. The cost of cyaniding would not be appreciably increased, and the flotation process would act as a final check against loss of partly extracted sulphides.

To Messrs. Richard A. Parker, consulting engineer, Ott F. Heizer, manager, and Jackson A. Pearce, superintendent, who have been responsible for the rehabilitation of the Argo mill, we are indebted for many courtesies extended in the preparation of these notes.

The Monitor Belmont Mining Co. is erecting a concentrating mill to treat silver ore valued at \$10 per ton at Belmont, Nye County, Nevada. The ore will be crushed by gyratory crusher, stamps and short tube-mills, the latter being 10 ft. long by 6 ft. diameter. Coarse concentration by gravity methods will be supplemented by oil flotation.

The *Testing of Materials* is the title of an 89-page booklet issued by the Bureau of Standards, Washington, D. C., dealing with such subjects as metals and alloys, cements, clay products, lime, stone, paint materials, inks, paper, textiles, rubber, leather, oils, chemicals and other materials intended for technical use. The pamphlet, which contains considerable of interest, is distributed free on request.

**Copper mining in Cyprus** is reported to have been undertaken by an American syndicate from Arizona. Work is to be started at Skouriotissa, about 60 miles from Larnaca. Arizona mining men will compose the operating staff.

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in December, 1914, was 63. The total quantity of ore milled during that period was 2,222,430 tons. There were 9807 stamps in operation, with an average duty of 9.03 tons per 24 hours. Tube mills in commission numbered 305. The yield for the month was 695,137 fine ounces gold. The total tonnage milled in 1914 was only slightly greater than in 1913. The yield for 1914 was 8,378,139 fine ounces, compared with 8,794,824 ounces in 1913.

## Furnace Curves

BY R. J. WEITLANER

Every step in the direction of reducing the consumption of fuel is not only an economical saving for the individual consumer, but also for the commonwealth at large, on the principle of the conservation of our natural resources. I am referring particularly to the immense amount of fuel used in the production of iron and steel. It is to this industry that the following article is mainly devoted, although it probably has a much larger scope.

Any fuel saving must be based on an accurate account or balance sheet of the fuel consumed in a metallurgical heating or melting process. This should enable the men in charge to judge whether fuel has been saved or has been unnecessarily expended.

Having worked for quite some time on furnaces for heating and melting steel, it occurred to the writer to try to accomplish this by means of so-called "furnace curves." The results were promising, and after plotting the fuel consumption on various heating and melting furnaces, these figures could be brought into certain relations with one another.

The conclusion drawn from a great number of furnaces, covering a sufficiently long period, was that *the fuel consumption of a furnace is a function of the furnace production in a certain time-unit.*

This time-unit can be made an hour, a furnace shift, a day, a week or a month, depending more or less upon the degree of accuracy with which the amount of fuel is or can be measured during said period, and further upon the more or less great regularity with which the furnace is working in this time.

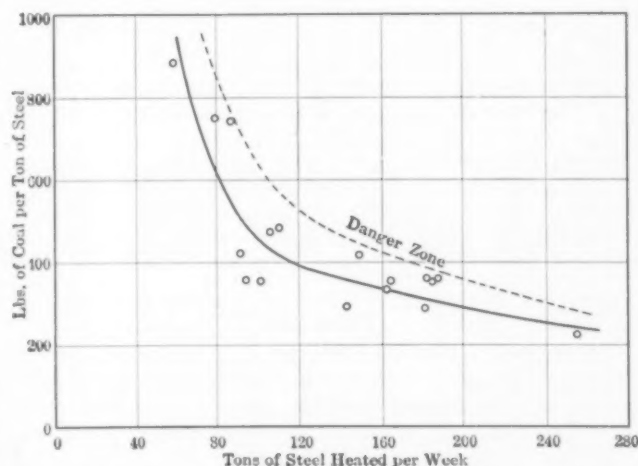


FIG. 1—FURNACE CURVE FOR COAL-FIRED HEATING FURNACE

Fig. 1 gives the furnace curve for a simple coal-fired heating furnace. The abscissas in this figure represent the tonnage produced per week, or more precisely, the tons of steel heated in this furnace during a week. The ordinates give the average fuel consumption for the same period in pounds of coal per ton (2000 lbs.) of steel heated.

Of course other units for production and fuel consumption can be chosen if more convenient as, for instance, pounds of fuel per pound of metal, etc.

The curve shown in Fig. 1 is an actual curve of a direct-fired coal furnace, and was obtained by carefully weighing the amount of coal for a number of weeks, the weekly averages being indicated by points and the curve drawn by taking the mean of all the points. Naturally all the points situated above the curve represent weeks where fuel for some reason or other was wasted:

all the points below indicate weeks where the furnace practice was better than the average.

It may, for instance, occur (see Fig. 2) that during one week we have a fuel consumption  $P_1$  of, say, 1100 lb. per ton of steel at a weekly production of 15 tons, and during another week ( $P_2$ ) the coal consumption may be 800 lb. per ton, but at a weekly tonnage of 31 tons. Yet in the first case the furnace practice was comparatively better than during the second week, as can easily be seen from the relative position of the two weekly points in reference to the average furnace curve. The saving during the first week over average practice was:

$$160 \text{ lb.} \times 15 \text{ tons} = 2400 \text{ lb. of coal.}$$

The loss during the second week amounted to:

$$80 \text{ lb.} \times 31 \text{ tons} = 2480 \text{ lb. of coal.}$$

This example should serve to illustrate the usefulness of furnace curves.

The shape of this and similar curves suggests a hyperbolic curve, and we readily see that with a smaller

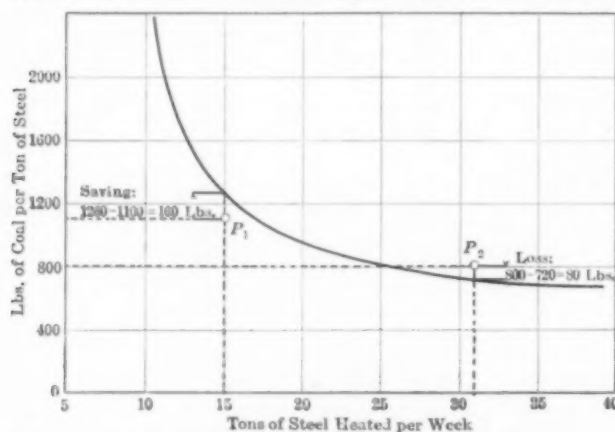


FIG. 2—FURNACE CURVE SHOWING RELATION OF FUEL CONSUMPTION TO WEEKLY OUTPUT

production the coal consumption per ton of metal increases rapidly, or, put into practical words, we have to allow the furnace-man a higher fuel consumption for a lower production, as indicated by the shape of the curve.

#### Construction and Accuracy of Curves Selection of Time Unit

Time and production units are so chosen as to give a well-shaped curve. This will especially be the case if a few points of extremely low and high production are available, that is points with simultaneous high and low fuel consumption, so that the branches of the curve are better defined. The majority of points should not be too far off from the nick or "apex" of the curve. The asymptotes are, of course, represented by the rectangular axes of the co-ordinate system (see Fig. 1).

The shape of the curve suggests at the same time at what production the furnace will work most economically; that is, we find that with decreasing production the fuel consumption increases rapidly, whereas on the other side, with a higher production, the decrease in fuel per ton becomes less and less marked.

The accuracy of the curves depends to a large degree on the accuracy with which fuel and metal is weighed or measured during a certain period. For furnaces heated by means of liquid fuel or powdered coal, where meters and automatic scales are provided, this problem becomes much easier and the resulting figures are more accurate, so that the readings should be made preferably after each twenty-four hours or better at the close of each furnace shift. By doing this we obtain a much greater number of points and the curve may be drawn

with great exactness. At the same time the influence of "stray points" becomes less marked and "fake points," caused by errors in figuring, are much easier detected.

If, for instance, the fuel was stored in large piles or bins, the best we can obtain will be weekly points. At the furnace-week's end the floor or the bins will have to be cleaned up or be filled up to a certain level to obtain a fairly accurate fuel figure.

We have two ways of keeping track of the available data. Using as ordinates the fuel consumption per ton

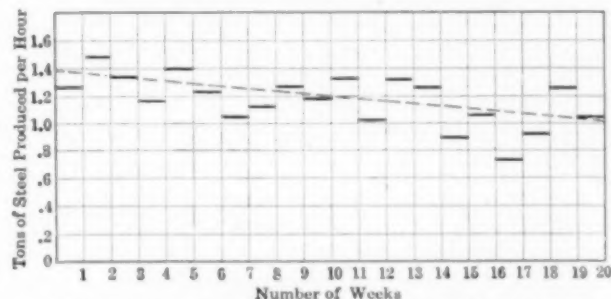


FIG. 3—INFLUENCE OF FURNACE AGE UPON PRODUCTION. ("AGE CURVE.")

of steel, we can either base it upon the entire weekly tonnage as abscissae (Figs. 1 and 2), or we divide the total tonnage by the number of hours the furnace was working and base our fuel consumption upon the tons of metal per hour (Fig. 5). In most cases this latter method will be the more accurate one, particularly if the furnace work is not continuous. With frequent intermissions of non-production or holding, it may even be necessary to deduct such fuel as was used during such intervals. In any case it will be of advantage to trace both curves, the one based upon total production, the other upon the hourly production.

#### Efficiency and Age Curves

If the temperature varies to which the material is heated, it will either be necessary to draw separate curves for the different temperatures or, better, to replace the fuel consumption by the term "efficiency," as outlined in the article on "comparative furnace efficiency" (see *Metallurgical and Chemical Engineering*, June, 1915, p. 357).

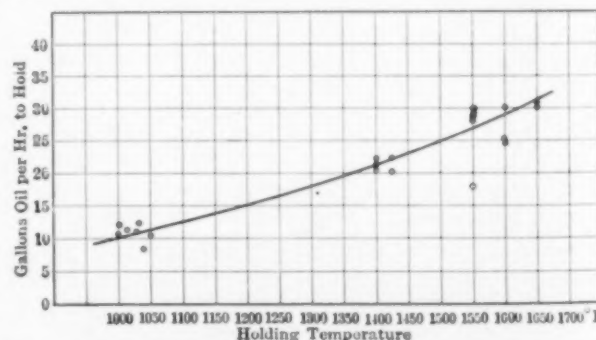


FIG. 4—INFLUENCE OF FURNACE TEMPERATURE UPON FUEL CONSUMPTION FOR OIL-FIRED HEAT-TREATMENT FURNACE

The latter method will particularly be adapted for such furnaces, where the temperature at which the metal is charged is higher than ordinary atmospheric temperature.

For melting furnaces with varying melting stock (pig iron, steel scrap, chrome scrap, etc.), either a number of "special curves" will have to be plotted, or a certain "heat content"  $a$  (B.t.u. per pound of metal,



see above article) will be agreed upon or determined by experiments and an efficiency curve constructed by means of it.

Such efficiency curves will also be required if, for instance, molten metal is charged into a melting furnace, although in most cases the exothermic reactions of the bath during the oxidizing period will possibly tend to cloud the fuel consumption proper.

Furnaces with a rather limited life, for example, open-hearth or crucible furnaces, will show a gradually decreasing production and increasing fuel consumption. It may sometimes be of interest to follow up this tendency by means of so-called "age curves," giving the furnace campaign week for week as abscissas and the correspondingly dropping production as ordinates (Fig. 3). It will then have to be ascertained how far the fuel consumption is influenced by the age of the furnace, besides such increases as is to be allowed on account of a lower production.

### Fuel for Heating Up and Holding

Separate records should be kept of such fuel as is required to keep the furnace at a certain temperature; for instance, in heat-treatment furnaces. In this case the fuel-consumption is preferably expressed by the amount burned per hour and then made a function of the furnace temperature by means of special curves as shown in Fig. 4. Each furnace, of course, will require different amounts of fuel to be kept at a certain tem-

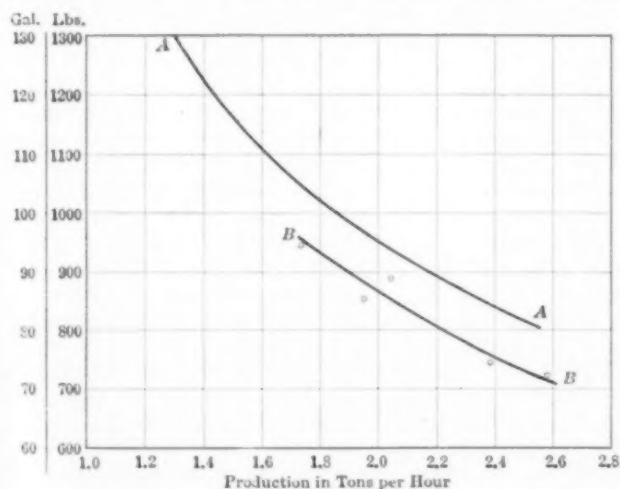


FIG. 5—COMPARATIVE COAL AND OIL CURVES FOR REGENERATIVE MELTING FURNACE OPERATED WITH PRODUCER GAS (A) OR OIL (B)

perature, depending upon the size and construction, etc., of the furnace.

If the fuel consumption per shift is kept separate and the furnace lit up every time at the beginning of the week, allowance should be made for a certain amount of fuel to be agreed on to bring the furnace up to the working temperature. A separate account should be kept of the fuel thus consumed.

### Change of Fuel and Fuel Comparison

It may often occur that one and the same furnace having a well-established furnace curve is changed over to another kind of fuel. We will then find that the new fuel curve runs almost parallel to the old curve, being merely raised or lowered according to the lower or higher heating quality of the new fuel. Fig. 5 gives an idea of such curves where a furnace was changed to oil fuel after having been on producer gas for some time.

We have thus an excellent means to compare different

grades of fuels as to their "thermic" value on one and the same furnace, even if the production during such periods should be at variance from points of the old fuel curve.

Fig. 6 shows a furnace curve of a coal-fired heating furnace, the average production of which with the old fuel was marked by the ordinate  $OP_1$ . The average coal consumption for this production was  $P_1C$  in pounds of

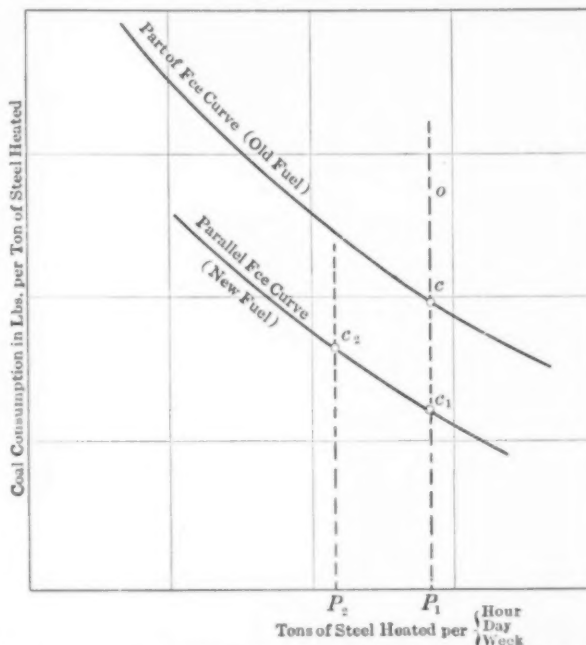


FIG. 6—FUEL COMPARISON FOR TWO DIFFERENT FUELS BY MEANS OF FURNACE CURVE

old fuel per ton of steel heated. A new fuel was introduced. The new fuel to which the furnace was changed over gave us a consumption  $P_2C_2$  for a production  $OP_2$  different from  $OP_1$ . Drawing through  $C_2$  a parallel curve to the old curve we obtain  $C_1P_1$  as the ordinate corresponding to the abscissa  $OP_1$ . The new fuel consumption, based upon the old average production ( $OP_1$ ), is now represented by  $C_1P_1$ , and the distance  $CC_1$  forms a

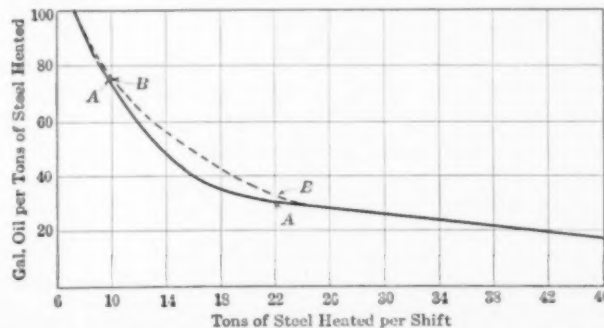


FIG. 7—COMPARATIVE FURNACE CURVES OF TWO FURNACES OF SIMILAR DESIGN—(OIL-FIRED BILLET-HEATING FURNACE)

measure of how much better the new fuel is than the original fuel. This, of course, merely indicates the heating and not the economical value of fuels, which latter shall be taken up separately.

Thus we see that with even varying production we are able to compare not only different brands of the same kind of fuel but also fuels of entire different origin.

### Individual Furnace-Curves

Having constructed a certain number of furnace curves, it will soon be manifest that each furnace has

its individual curve, and that hardly two furnaces, even of apparently identical design, will have the same curve. The curves will almost always show slight variations in their fuel-consumption for varying production. This is plainly illustrated by comparing the two curves of two billet heating furnaces of similar construction, given in Fig. 7, where the fuel consumption of furnace A with a production of 10 to 20 tons per shift is decidedly lower than that of the B furnace. This may be an indication of certain slight variations in the construction of the furnaces, their stack draft, etc., which differences may have escaped notice heretofore.

In future it may be found practical to use instead of the more average fuel consumption, the characteristic furnace curves in connection with average production and fuel consumption.

### Selection and Criterion of Furnaces

If a number of curves of furnaces which are not of similar construction but are used for approximately the same kind of work and production, are plotted on a sheet, using the same units for production and fuel consumption, we will notice wide discrepancies even for similar production. We therefore will try to use such furnaces which indicate the lowest consumption of fuel for certain productions if a selection of furnaces is possible.

By comparing curves of different furnaces we may even be able to draw some conclusions in regard to their construction, for instance the ratio of length to width, furnace volume, tonnage, slope, draft conditions, fire chambers, etc.

According to the curves in Fig. 7 of two similarly built billet-heating furnaces A and B, the furnace A shows a much lower fuel consumption than B at the same production. Since both furnaces were turning out same material the difference in the curves must be caused by some differences in their construction or location. In fact, certain imperfections in the location seemed to justify this conclusion.

### Bonus and Cost System

After these remarks regarding the characteristics of furnace curves in general I call attention to the practical purpose for which they can be used with great advantage in my opinion.

*The keeping and following-up of furnace curves seems to me the only just way upon which a bonus and penalty system should be based, if such is contemplated. We are thus able to read off with almost theoretical exactness how much fuel was either saved or wasted in a certain period. If expressed in dollars and cents this system allows us to pay a certain percentage of the saving to the man responsible for the handling of the furnace or to impose penalties for any wastage of fuel.*

From the foregoing it is plain how the gains or losses expressed by the amount of fuel are determined. I may add that the work of keeping track of such gains or losses may be greatly facilitated if we mark on the same furnace sheets graphically the fuel costs.

If, for instance, different grades of coal and of various prices are used on a furnace, we will be able to read off the actual amounts of savings or losses in dol-

lars and cents on the "price lines" as shown on the right side of Fig. 8. We merely draw a horizontal line through A representing 1120 lb. or  $\frac{1}{2}$  gr. ton of coal and measure off from A various ( $\frac{1}{2}$ ) coal prices and connect with 0.0, thus obtaining price lines for any coal price. If, to give an example, one of our weekly points P should fall below the curve, we will draw two horizontal lines, through P and the ideal point P' of the same production (6 tons) and can now read off the actual heating or melting costs on the corresponding price lines, or as in this case on the same price line (\$2.50 per gr. ton of coal) if the fuel price for P was the same as that for the curve. The difference of the two readings \$0.61 — \$0.50 = \$0.11 tells us the cost of fuel (lost or) gained, above or below average practice.

If on a furnace, heated with oil or powdered coal, the fuel-readings can be made at the end of each furnace turn, it will be of advantage to add up all the gains and losses made by each heater, and to pay bonuses at the week's end.

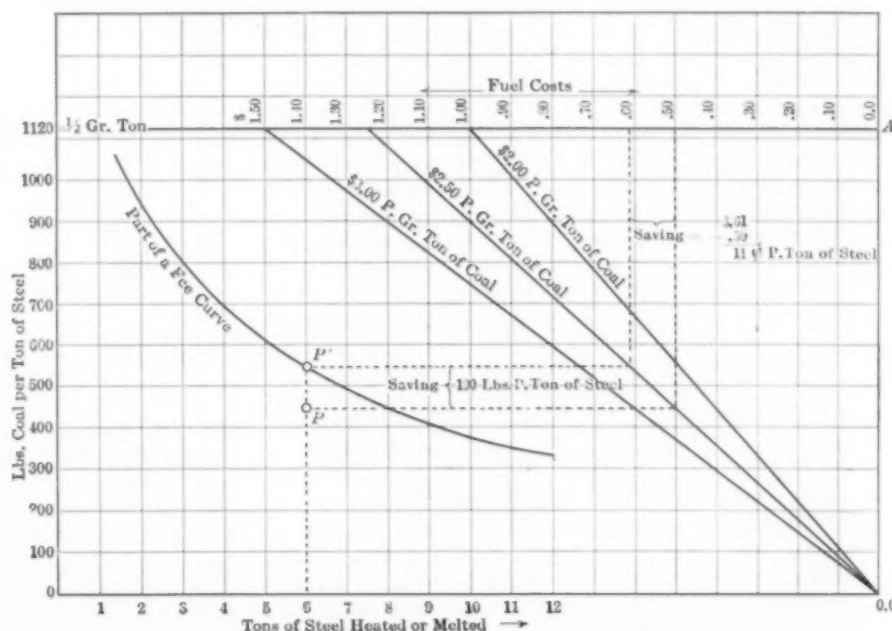


FIG. 8—FUEL COST DIAGRAM FOR VARIOUS FUEL PRICES

Should the variations from the curve be too great a so-called "danger zone" may be agreed upon, within which the points above the curve should come to fall, without imposing a penalty for such moderate losses. The dotted line in Fig. 1 suggests such a danger zone.

To sum up in the furnace curves we have a system enabling us to judge the performances of our industrial furnaces which is not only just from the manufacturer's standpoint but is also fair to the men at the furnaces.

If a furnace bonus system should be adopted and put into practice the effect will very likely be that through the endeavor of the men more and more points will come below our medium curve and thus a new improved curve will be established, which then may form the standard for future practice.

### Résumé

1. Furnaces have individual curves, their fuel consumption being a function of their production in a certain time period.
2. These furnace curves should be used to determine whether fuel has been wasted or saved during a certain working period and to serve for comparing furnaces as well as fuels.
3. A bonus system can be based upon such curves.



## Blast-Furnace Plant Auxiliaries and General Arrangement

BY J. E. JOHNSON, JR.

(Continued from page 378.)

### The Dry Blast

This subject has aroused within the last ten years more comment and controversy than any other connected with the blast furnace. In dealing with the thermal principles of the furnace I shall endeavor to show that the claims for economy made on behalf of the dry blast are well founded, and in treating with the question of operation I shall endeavor to discuss the considerations other than those of fuel economy which affect the subject and must be considered before reaching a correct decision in regard to this matter. Here we have only to do with the design and construction of the plant if its installation be decided upon.

It is well known that the atmosphere contains moisture, but the laws under which the moisture exists are probably less widely understood than any others dealing with a subject which affects our daily life so much.

According to Dalton's law two or more vapors or gases can, in fact and in principle, occupy the same space at the same time, and each acts exactly as though the other were not there. That is to say, if we have two cylinders holding one cubic foot each, one of them containing nitrogen sufficient to exert a pressure of twelve and a half pounds per square inch on the inner surface of the cylinder (that is not pressure above the atmosphere but absolute pressure) and another containing oxygen sufficient to exert a pressure of two and a half pounds per square inch absolute, and pump the contents of the second cylinder into the first, each gas will continue to exert the same pressure that it did before, but in this case they will both be exerted on the walls of the same cylinder, and we shall have a nitrogen pressure of twelve and a half pounds, plus an oxygen pressure of two and a half pounds, or a total of fifteen pounds per square inch. Similarly if we have a cylinder containing a cubic foot of water vapor at an absolute pressure of half a pound per square inch, and pump that into the first cylinder we shall have a total pressure of fifteen and a half pounds per square inch, and if the cylinder were opened part of the mixture would flow out until the total pressure was down to atmospheric pressure, but the gases and the vapor would be present in the same proportions as before.

This on the assumption that the temperature is high enough to produce a vapor pressure of half a pound, and here we come into complications because the pressure of the vapor depends entirely upon the temperature, or at least is limited absolutely by it. It can never be more than the pressure corresponding to the given temperature, but it may be, and in the atmosphere generally is, less. For our present purpose it seems to me to simplify matters to consider the air not as containing vapor but as acting simply as a carrier for it. That is to say, if we handle ten thousand feet of air the water vapor in that air must go with it, though not in the chemical sense dissolved therein.

The determination of the quantity of moisture actually present in the atmosphere may be made in several ways. The simplest is to cool some glass or metal cup or vessel containing a thermometer by some form of artificial refrigeration very slowly, and note the temperature at which visible moisture begins to settle upon it. This is known as the dew point, and knowing this we can easily take the weight of vapor per cu. ft. directly from the vapor tables, which the United States Weather Bureau publishes in very comprehensive and satisfactory form. This, however, is not the method

generally recommended for obtaining the dew point. As the result of very extensive investigations it has been stated by practically all the authorities that the wet-and-dry bulb thermometer furnishes by far the most satisfactory and reliable information. The theory of this instrument and the tables for its use have been set forth very thoroughly both in government publications and in a paper by Mr. W. H. Carrier of Buffalo before the American Society of Mechanical Engineers in Vol. 33, 1911, the latter being particularly valuable.

The quantity of moisture in air is usually given in grains per cubic foot, but this is an exceedingly unsatisfactory unit for blast furnace work because the other quantities with which we are concerned are measured in tons and pounds, but certainly never in grains, and as the effect of water vapor is purely a quantitative one it is very desirable to have it expressed in the same units as those used for other quantities involved in furnace operation. For this purpose pounds per thousand cubic feet of air are by all means the most desirable, and as there are exactly seven thousand grains in a pound avoirdupois we have only to divide the grains per cubic foot of the ordinary tables by seven to convert the results to pounds per thousand cubic feet.

Here a point of much importance arises. Air is very commonly measured at 32 deg. F., but when its temperature is raised to say 70 deg. F. its volume is increased about 8 per cent, and as the quantity of moisture increases directly as the volume, the moisture content of a cubic foot of saturated air at 70 is greater than that of the same weight of air at freezing, not only because of the increased density of the water vapor but because the carrying space in which this vapor exists is simultaneously increased.

In 1906, soon after the first announcement of the success of the dry blast, I published before the (British) Iron and Steel Institute, a paper entitled "Different Modes of Blast Refrigeration, and their Power Requirements," in which was given a chart showing the weight of water vapor per 1000 cu. ft. of air at temperatures from minus 20° to plus 80° F., but as this question of cubic feet is very troublesome, because we must always state the temperature at which the air is supposed to be measured, I converted this to 75 lb. of air which is the weight of atmospheric air at 70 deg. F. and standard barometer. This chart is shown in Fig. 2, from which it will be seen that the moisture content at saturation per 75 lb. of air rises from 0.07 lb. at zero F. to 1.14 lb. at 70 deg. F.

As normal air is about two-thirds to three-fourths saturated and as the temperature in summer may easily rise to 85 deg., it is very obvious that we have in Summer to deal with moisture sometimes reaching a pound or more per thousand cubic feet, and such is the case in many northern iron producing districts, the average moisture for some months being nearly a pound, while in Alabama the conditions are much worse than this, a pound and a half per thousand cubic feet being not unusual.

Accepting it as proven for the present that the action of moisture on the operation of the blast furnace is exceedingly detrimental, and realizing that the above figures indicate that we may easily be pumping 50 lb. or 60 gal. of moisture per minute into a modern furnace with the blast, the question obviously arises, how shall we eliminate it?

The metallurgical world now knows how the question was solved after many years of experiments by James Gayley at the Isabella furnaces in Pittsburg, the moisture being condensed out of the air by artificial refrigeration. Obviously, since the quantity of moisture in saturated air rises with great rapidity, with rise of temperature as shown in Fig. 1, we have only to lower

the temperature to cause the precipitation of the moisture. In practice we have to do more than this, since lowering the temperature tends to precipitate the moisture as fog, which in its form of water mechanically suspended may easily pass with the rapid current of air through the refrigerating apparatus and thus to the blowing engines and the furnace. Care must therefore be used in the design not only to condense the moisture but to precipitate it out in drops large enough to leave the air. Preferably the drops should form on the refrigerated surfaces and drip from these in such a way that the air current can not pick the drops up again.

Refrigeration requires power, and what is more serious it requires the investment of capital. Therefore it is very important to design the refrigerating plant to use the least amount of power possible since this will in general mean the smallest capital cost also, and the capital cost of this process has been its greatest disadvantage.

The original dry blast plant, that at the Isabella furnaces of the United States Steel Corporation, was of the brine circulation, single-stage type for the reason that in the vast metallurgical experiment upon which Mr. Gayley was engaged, he felt compelled to take the

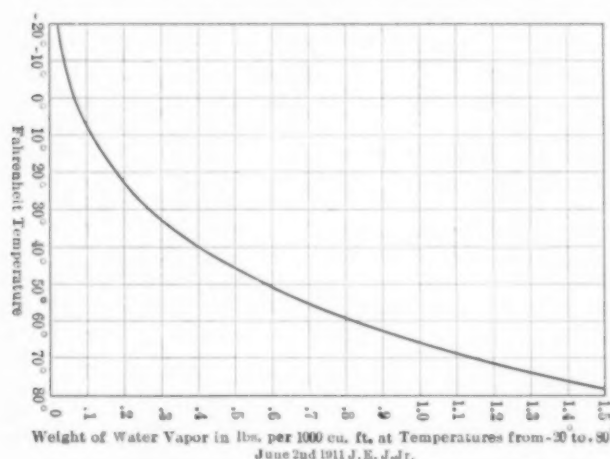


FIG. 2—CHART SHOWING WEIGHT OF WATER VAPOR PER THOUSAND FEET OF AIR AT SATURATION AT DIFFERENT TEMPERATURES

simplest and easiest means to accomplish the result, irrespective of whether they were the most economical, and on account of the success of this system at the Isabella plant, and of some failures of early attempts to improve upon it, the same system was used for all the early dry-blast plants. Briefly this system is as follows:

The ammonia vapor is compressed by a steam-driven compressor and condensed in a standard ammonia condenser, from which it passes to a brine cooler where it is evaporated, absorbing the necessary heat for evaporation from the brine and thereby cooling the latter. The brine, a solution of salt or calcium chloride with a freezing point many degrees lower than that of water is then circulated through other coils in a huge chamber through which the air passes on its way to the blowing engine, the air being blown into the chamber by a large fan and removed from it by the suction of the blowing cylinders. Ice forms on the coils, which soon reduces their cooling power and obstructs the passageways for the blast. This necessitates putting out of commission each of the coil chambers in turn every few days while it is thawed off by steam, an expensive operation since not only the steam but the ice cost coal, and the operation of thawing itself takes some time and labor.

A plant of this type designed by Frank C. Roberts & Co. is shown by Fig. 3. The captions under the different views render them very easy of comprehension.

A careful study of the refrigerating process makes it obvious that this system of refrigeration is capable of great improvement, both from the point of view of first cost and that of power requirements. The general principles controlling this whole matter were pointed out at some length in my paper before mentioned, part of which is reproduced below.

It is well known that the power required for a given quantity of refrigeration per minute,  $Q$ , is theoretically

proportional to  $\frac{T_1 - T_2}{T_1}$ , where  $T_1$  is the absolute temperature (Fahrenheit + 460 deg.) at which the heat is absorbed by the system and  $T_2$  that at which it is rejected, the expression being

$$HP = \frac{778}{33,000} Q \frac{T_1 - T_2}{T_1}$$

where  $Q$  is measured in B.t.u. per minute.

The ammonia-compression refrigerating machine having so largely supplanted all others for land service, we shall consider only that type. Upon it, fortunately, reliable investigations have been made which enable us to establish a relation between its theoretical and its actual performance, and this goes far to answering our questions.

In the original paper reference was made to the work of Professor Denton in New York and Professor Schroter in Munich on tests of the power consumption of refrigerating machines, but a much more extensive series of tests have since been conducted by the York Manufacturing Company, under the direction of Mr. Thomas Shipley, their general manager, and the results of these tests have been collected and plotted in a paper on "The Power Required for Refrigeration" (*Metallurgical and Chemical Engineering*, December, 1912) and the diagram giving these results is substituted as Fig. 4. The

coefficient of  $\frac{T_1 - T_2}{T_1}$  based on these results becomes 3.7 instead of 4.15 corresponding to a smaller indicated power than shown in the earlier results. The difference is not great for the conditions of blast refrigeration and makes power estimates based on the subsequent curves in this quotation somewhat high and correspondingly safe.

Tests on both wet and dry compression were given in the original paper but now the dry is so much superior that the wet compression tests have been dropped and allusions to them omitted.

For a number of tests in each of these series I have calculated the theoretical horse-power by equation (1), and compared it with the actual indicated horse-power of the steam cylinders, the ratio of the latter to the former being called  $R$ , it being, in fact, the reciprocal of the efficiency on this basis.

These values of  $R$  have been plotted as ordinates with the corresponding values of  $\frac{T_1 - T_2}{T_1}$  as abscissas, as shown on Fig. 4.

The values of  $R$  plainly decrease with the value of  $\frac{T_1 - T_2}{T_1}$ , and it is clear that when the temperature range is zero,  $R$  should be 1, the efficiency being perfect. Accordingly, a straight line has been drawn passing through the point  $\left(\frac{T_1 - T_2}{T_1} = 0, R = 1\right)$

and this line coincides with the points with surprising accuracy, and may be taken as expressing the law of this relation correctly.

As these tests represent widely varying conditions in



each series, it is clear that there is a trustworthy connection between the conditions of refrigeration and the power required for it in any case.\*

obviously the most convenient basis, but we are at once confronted with the difficulty that, as we change the temperature of the air, we change the volume of a given

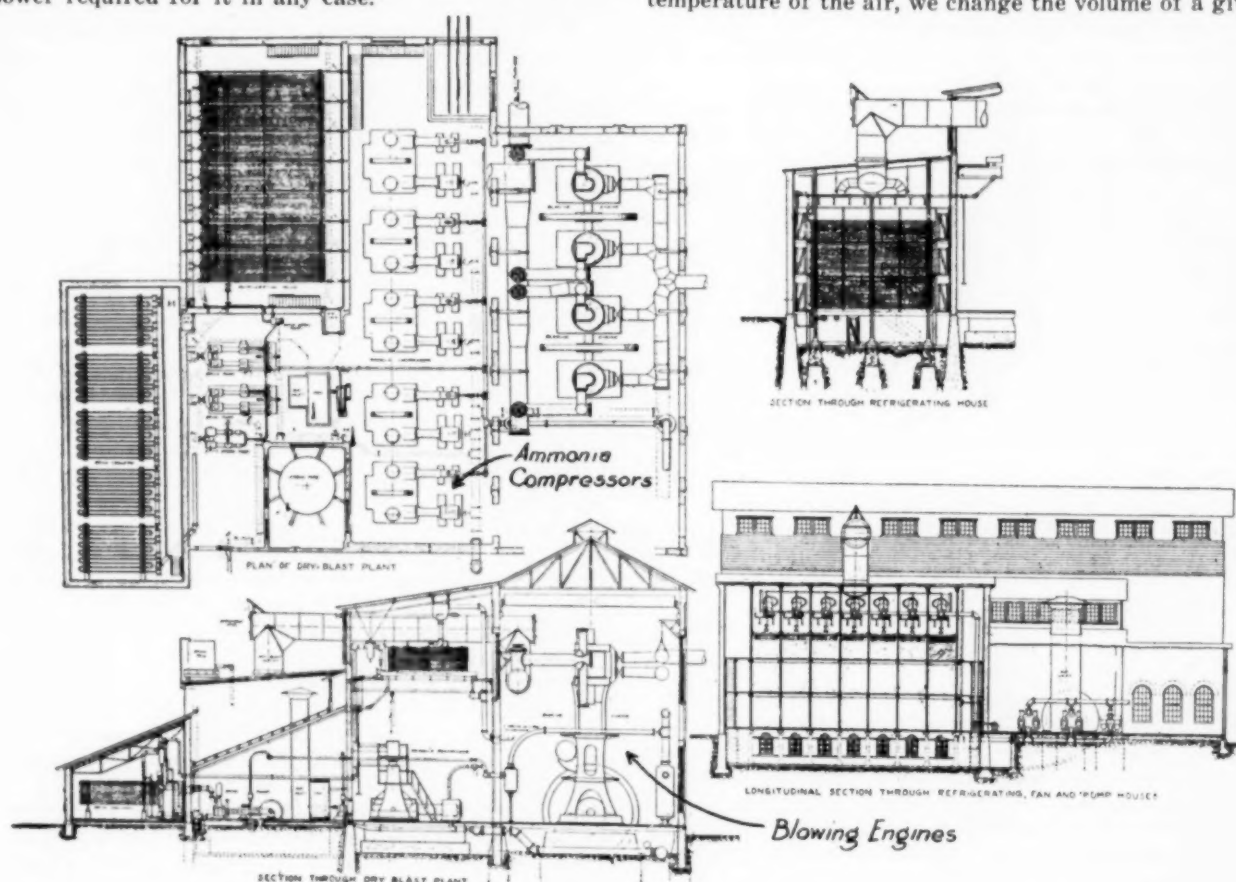


FIG. 3—DRY-BLAST PLANT DESIGNED BY FRANK C. ROBERTS & COMPANY, SINGLE-STAGE, BRINE-CIRCULATION, NON-REGENERATIVE

The algebraic expression of these values is

$$R = 1 + 4.15 \frac{T_1 - T_2}{T_1}$$

The relation between temperature range and power requirements for a given quantity of heat having been determined, we need only to know in addition the quantity of heat to be removed to determine the actual horsepower required.

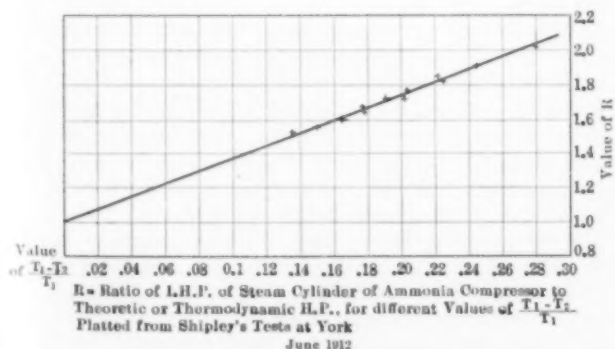


FIG. 4—CHART SHOWING RATIO OF ACTUAL TO THEORETICAL HORSE-POWER REQUIRED FOR REFRIGERATION WITH DIFFERENT TEMPERATURE RANGES

The quantity of blast used being commonly measured in thousands of cubic feet per minute, the quantity of heat required to be removed per 1000 cu. ft. of blast is

\*Although this seems such an obvious means of determining the actual power requirements in any case, when the general conditions are known, it is entirely new, and has never been used by refrigerating engineers, so far as known to me.

weight as well, 1000 cu. ft. at 70 deg. F., becoming 900 cu. ft. at 21 deg. F.; so that in considering the quantity of water-vapor contained in the blast as affected by re-refrigeration we not only diminish it by the fact that a cubic foot of space will contain less moisture at 21 deg. F. than at 70 deg. F., for instance, but that there are only nine-tenths as many cubic feet for a given weight of blast.

To overcome this difficulty the standard temperature at which blast is measured is taken at 70 deg. F., at which 1000 cubic feet of air weigh exactly 75 lbs., and all calculations are based on 75 lbs. of air, correction being made for variation in volume.

For the convenience of those desiring to make calculations on blast drying, a diagram (Fig. 5) is given herewith, which gives various relations of this standard quantity of air, based on its temperature.

The lower half of the diagram contains three curves whose abscissæ are temperatures, and their ordinates quantities of heat above 0 deg. F.

The straight line I shows the sensible heat, above that at 0 deg. F., of 75 lbs. of air at any given temperature.

The upper curve gives the quantity of heat present above 0 deg. F. in the water-vapor which will saturate 75 lbs. of air at different temperatures.

The latter quantity is not that given in steam tables as the "total heat of steam," but represents as nearly as may be the heat which would require to be removed by refrigeration in order to reduce the vapor present in the air to the quantity sufficient for its saturation at 0 deg. F.

This is made up as follows, for temperatures up to the freezing point:

1. The sensible heat of the ice above 0 deg. F. (the specific heat taken as 0.50).
2. The latent heat of freezing.
3. The heat of vaporization.

These are all to be taken for the given temperature and the quantity of moisture actually present in 75 lbs. of air at that temperature.

Above the freezing point the conditions are altered; for part of the water, as soon as condensed, will not wait to be cooled down to the temperature of the refrigerating coils, but will drip off them soon after its deposition. As a fair estimate, therefore, one-half of the sensible heat (above 32 deg. F.) for all the vapor in excess of that present at freezing is added to the other items.

This is shown in the diagram curve II.

The lower curve III is located by adding the ordinates of the first two and represents, therefore, all the heat requiring to be removed to reduce the air from saturation at a higher temperature to saturation at 0 deg.

The small quantities of heat  $\Delta Q$ , of which these larger quantities are made up, are each removed at a different temperature, and therefore correspond to a different  $T_1$  in formula (I); hence these total quantities cannot be applied directly in that formula, but the latter must be put into the form

$$HP - R \frac{778}{33,000} \Delta \left( \frac{T_1 - T_2}{T_2} \right)$$

and integrated in order to give numerical results. This would be so tedious a process as to be useless if done analytically, but may be done conveniently by the application of the entropy diagram invented by Professor J. Willard Gibbs of Yale University many years since, and brought to the attention of the engineering world at large some fifteen years ago by Mr. Macfarlane Gray of England.

To many it will be a matter of indifference how the results are reached, provided only that they are reached correctly and swiftly. To these it may be said that entropy is a mathematical quantity depending upon heat and temperature such that, when any thermal operation is plotted with temperature for abscissæ and entropy for ordinates, the mechanical work involved is represented by the area included, precisely as it is with co-ordinates of pressure and volume in the ordinary indicator-diagram. This quantity has been determined for 75 lb. of dry air, for the vapor contained in it, and for the sum of these, exactly as for the corresponding quantities of heat, and these are plotted on the upper side of the same temperature axis as the latter. These curves are numbered respectively IV, V and VI.

The theoretical or perfect cycle of operations of the ammonia compression machine is represented on this diagram by a rectangle whose right-hand end is the ordinate at the condensing temperature of the ammonia. Its top is a horizontal line at a height determined by the total entropy of the air to be refrigerated, and its bottom one at a height determined by the entropy after refrigeration. (These will be called hereafter the lines of maximum and minimum entropy respectively.) Its left-hand end is determined by the suction or absorption temperature of the ammonia, which must be low enough to absorb heat from the air at the lowest temperature to which the latter is to be reduced. In practice the suction temperature is never less than 10 deg. F. lower than this; and similarly the compression or condenser temperature is never less than 10 deg. higher than that of the condensing water.

Under normal conditions cooling water at 70 deg. F. to 75 deg. F. will always be available for condensing purposes in hot weather, and the maximum condenser temperature used in these diagrams is accordingly 85

deg. F.; also, in all the cases taken for analysis in this article, this is the condenser temperature assumed, unless otherwise stated.

If we assume a uniform difference of temperature of 10 deg. on the two sides of the expansion coils, we might construct a curve lying uniformly 10 deg. F. to the left of the total entropy curve, that is, having a temperature 10 deg. F. lower for the same ordinate in each case, and the lower left-hand corner of every rectangle would lie on this line, thus determining the rectangle completely, as the top and bottom lines are in all cases the lines of maximum and minimum entropy, and the right-hand end is the condenser temperature as before, the left-hand end being then determined by the intersection of the line of minimum entropy with the proposed curve.

This curve, however, is not drawn on Fig. 5 for the reason that the area of the rectangle so determined would have to be multiplied by  $R$ , which would have to be determined from the absorption and condenser temperature in each case, in order to give the actual power required.

In order to avoid this necessity three auxiliary curves are plotted in dotted lines, which give the actual power requirements direct, with an assumed temperature difference in all cases of 10 deg. F. at the refrigerating coils, and with three different condenser temperatures, respectively 85 deg. F., 70 deg. F., and 55 deg. F., corresponding to the temperature of cooling water available under different conditions and at different seasons.

The simple rule for the use of these curves is: Draw the lines of maximum and minimum entropy, both extending to the proper condenser temperature on the right, and the latter extending to the left to its intersection with the corresponding dotted curve; at this point erect the vertical which completes the rectangle. The area of this rectangle in square inches gives the horse-power required per 75 lb. of air for refrigeration between the limits chosen.

At various heights on the diagram the difference in temperature between the entropy curve and the assumed condenser temperature is taken, increased by 10 deg. F., and the sum multiplied by  $R$  as determined from  $\frac{T_1 - T_2}{T_1}$  for that point. This product is not in any way

to be considered as a temperature, but only as a length, and is set off to the left of the condenser temperature used, with the ordinate for which the temperature difference was taken.

These points are connected by the dotted curves, and when the left end of the rectangle is drawn upward from the intersection of lines of minimum entropy with the appropriate curve, its right end and top being, as before, the condenser temperature chosen and the line of maximum entropy, it is evident that the length (and therefore the area) of the rectangle has been increased in the ratio  $R$ , thus giving actual horse-power.

In using these curves care must be taken to use the one corresponding to the condenser pressure in the given case. If this be different from any of those given, the curve corresponding can be interpolated by eye with all the accuracy necessary for most purposes.

It must also be noted that the curves are only correct for the "direct expansion" system, that is to say, where the ammonia is expanded in the coils over which the air passes.

In the brine-circulation system the ammonia is expanded in coils immersed in a tank of brine, which is afterwards circulated through coils in the refrigeration chamber.

It is obvious that this system requires twice the expense for coils or pipe surface, and also requires twice



the temperature-interval between the temperature of the expanding ammonia and that of the air, required by the direct-expansion system, since the heat requires to be transmitted through the walls of two sets of pipes instead of one.

It is for the latter reason that the curves given are not correct for the brine system. To make them correct for this case at least 20 deg. F. should be added, instead

of 10 deg. F., to the difference of temperature between the points on the entropy curve and the condenser temperature. This of course would give a new value of  $T_1 - T_2$  and a new and larger value of  $R$  to correspond,

so that the length of the rectangle for this case would be very materially augmented.

This, of course, means that the power required would

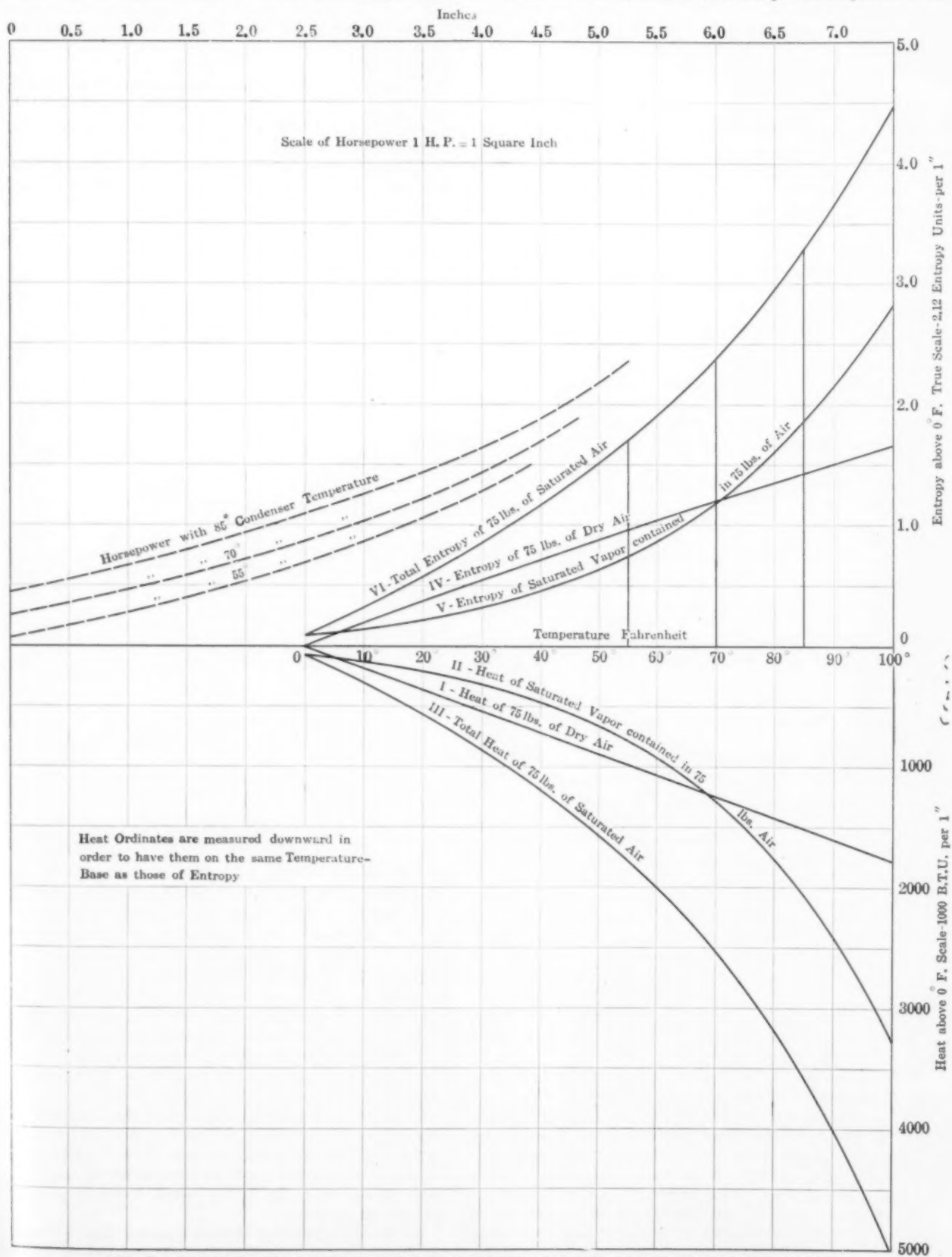


FIG. 5—TOTAL HEAT AND TEMPERATURE ENTROPY DIAGRAM OF AIR AND WATER VAPOR

be augmented in the same degree, and the cost of equipment in the same degree also, or even more, owing to the high cost of the second set of cooling coils in addition to the increased compressor capacity required.

The danger to persons in the cooling chamber, from the escape of ammonia in direct expansion, is a minimum, since no one is ever required to enter it during operation and but seldom at any time; the danger of explosive mixtures of ammonia with air does not exist, and the charge would be no more irrevocably lost in the blast in the cooling chamber than in the brine tank, in case of a bad break in the coils.

Only one possible danger exists, which is, that brass parts in the path of the blast would be rapidly destroyed if persistent leaks of ammonia occurred; but as the use of brass or bronze in such a situation is unusual and may readily be avoided altogether this is not a serious matter.

Under all circumstances there does not seem to be a sufficient reason for the use of the brine circulation now that the process of blast-drying is an established success and the need for the precautions required in an experimental plant no longer exists.

It is my conviction that, for the reason given above, the eventual progress of blast-drying will be along the lines of direct-expansion, and the curves of Fig. 5 have, therefore, been calculated on this basis. Should any one desire them for brine circulation they can readily be calculated from the entropy table given and the formula for the value of  $R$  using a temperature difference for heat-transmission of 20 deg. F. or 25 deg. F., as might be found most consonant with the results of other experience with brine-circulation systems.

It might be as well to point out that the "total entropy" curve does not give the entropy for anything but saturated air; if the air be not saturated (as it generally is not), it is necessary to know both the dew-point and the temperature in order to determine the entropy. In that case the entropy of the water-vapor alone at its dew-point must be taken from the "entropy of vapor" curve and added to the entropy of the air at its temperature, as taken from the "entropy of dry-air" curve. This is most conveniently done with dividers. The total entropy so determined will be above the total entropy curve at the dew-point temperature, and below it at the air temperature.

In regards to the temperature to which the air should be refrigerated some consideration is necessary. In Fig. 2 is given a curve showing the quantity of vapor present in 75 lb. of saturated air at various temperatures. From this it is evident that the reduction in the weight of vapor for each degree the temperature is lowered is very slow after 25 deg. F. is passed, and even at 32 deg. F. is not rapid. At the same time the horsepower curves show that the power requirements increase rapidly for very slight reductions of temperature, and it is evident that the ratio of expenditure to gain is increasing so enormously that the balance point is soon passed.

This is shown by Fig. 6, in which is plotted the ratio of water removed from 75 lb. air to the power required for its removal below 40 deg. F.

This is based on 70 deg. F. condenser-temperature and single-stage non-regenerative refrigeration.

The saving in fuel in the furnace is directly proportional to the water removed, and the cost of plant and its operation nearly proportional to the power required, so it will readily be seen from Fig. 6 that a limit must soon be reached from the commercial point of view.

In summer all the uniformity possible would be reached by refrigerating to 32 deg. F., and all trouble from ice formation would be avoided by not going below this point.

As the weather became colder and the dew-point fell so as to be sometimes below this point, the diminished refrigeration required, and the lower temperature of cooling water available, would enable the same plant to maintain a lower temperature and still retain the uniformity desired by reducing the temperature of the air below the lowest natural dew-point probable.

This change being entirely under control of the manager would lead to no sudden changes, and would give a coke consumption in summer so nearly the same as that in winter that the difference would probably be inappreciable.

As between a refrigeration temperature of 32 deg. F. and one of 22 deg. F., with a blast temperature of 1000 deg. F. and normal coke practice, the saving for the latter would be about 2 per cent.

Using this chart as an implement of investigation we may now proceed to examine various methods of refrigeration.

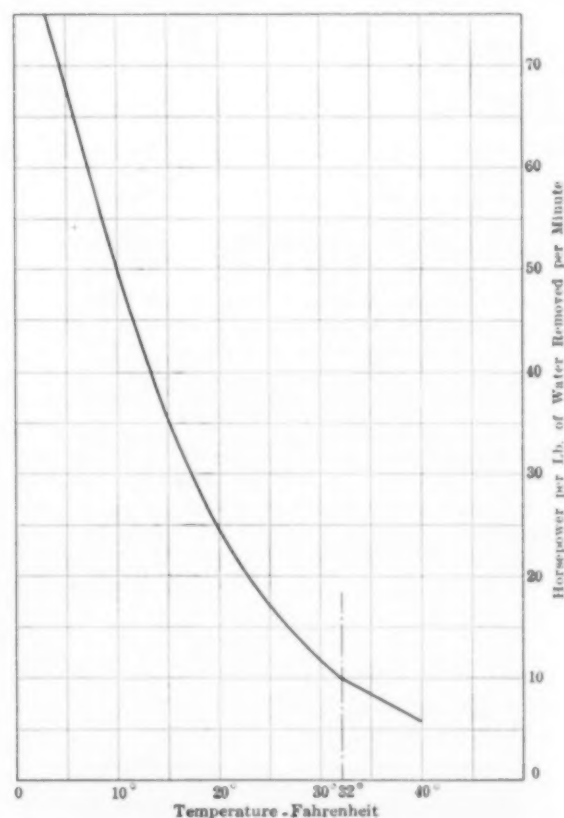


FIG. 6—HORSE-POWER REQUIRED PER POUND OF WATER REMOVED PER MINUTE IN REFRIGERATING BLAST TO TEMPERATURE BELOW 40 DEG. FAHR.—(DIRECT EXPANSION, SINGLE-STAGE, NON-REGENERATIVE REFRIGERATOR, CONDENSER TEMPERATURE 70 DEG. FAHR.)

In order to represent these methods graphically, and at the same time avoid marring the diagram, Fig. 5, for independent use, it is reproduced in Fig. 7 with the rectangles representing the cases to be discussed drawn upon it.

In order to facilitate comparison and reference certain data corresponding to frequent summer conditions, namely, a temperature of 85 deg. F., and a dew-point of 70 deg. F., a condenser-temperature of 85 deg. F., and that the air is to be refrigerated down to 25 deg. F., may be assumed.

Let us also draw for convenience on Fig. 5 the line of 10 deg. F. temperature-difference parallel to the curve of total entropy (VII).



The conditions assumed are then represented on the diagram by the figure *JadH*.

The rectangle drawn for these conditions is *ZJHG*, and its area is  $5.60 \times 1.89 = 11.56$  sq. in., corresponding to 11.56 hp for drying 75 lb. of air between the limits and under the conditions assumed.

It is evident that the area below the curve of total entropy and the line of maximum entropy, above the line of minimum entropy, and to the left of the line of

condenser-temperature, represents the theoretical minimum work for the performance of that amount of refrigeration. This must be increased in practice by moving the curve of total entropy 10 deg. F. to the left to give the necessary temperature-head. This is the curve of 10 deg. F. temperature-difference on Fig. 7, and is approximately a diagonal line across the diagram, making the area roughly triangular. On the other hand, the energy-diagram of the ammonia refrigerating cycle

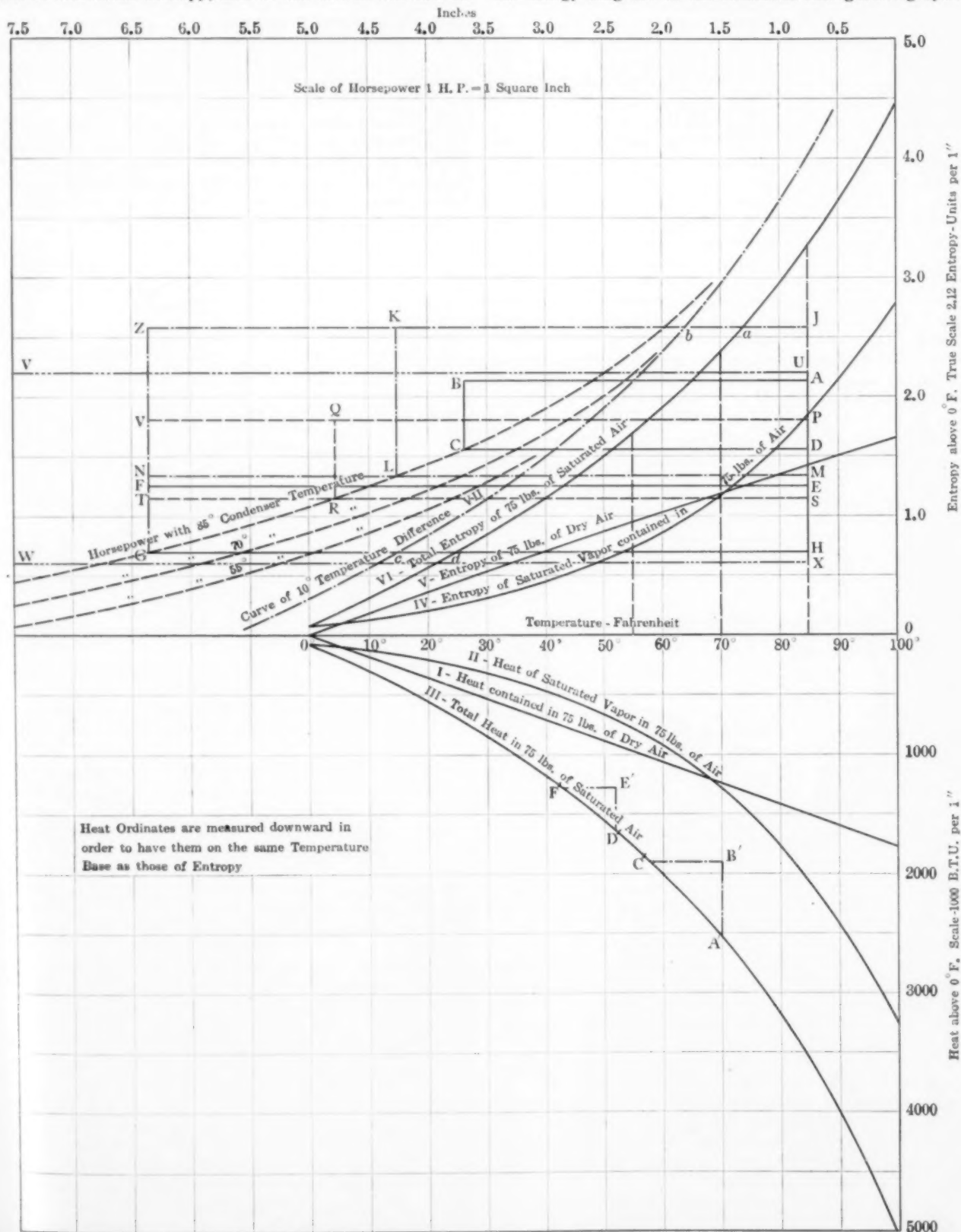


FIG. 7—TOTAL HEAT TEMPERATURE ENTROPY DIAGRAM APPLIED TO DETERMINING POWER FOR DIFFERENT METHODS OF BLAST REFRIGERATION

is, as already stated, a rectangle, and as it must be as large in every direction as the diagram of energy required, it is obvious that there must be a large quantity of waste room in the former diagram and that, accordingly, energy is being wasted.

This is also evident from an inspection of Fig. 2 since this shows that of all the moisture contained in the air at 70 deg. F. half is precipitated when the temperature is lowered to 50 deg. F., and of that removable down to 25 deg. F. almost two-thirds, yet the heat of all this is removed at the temperature of 25 deg. F.

This is precisely as if, in pumping from a shaft 45 feet deep, in which three-fifths of the water entered in the upper 20 feet, we put one pump at the bottom and let all the water run down to that level before pumping it out. It is really much worse than this, because in pumping heat the power required increases much faster than the head, while with water this is not so.

The remedy is as obvious in refrigeration as it is in pumping, to have two pumps, catch the greater part of the heat near the top of its scale and pump it out from there, pumping from the lower level only the heat which comes in at or near that level, a much smaller quantity.

This means the use of two ammonia compressor-cylinders, one working from the 15 deg. F. suction-temperature as before, the other working from a much higher suction-temperature, say 36 deg. F., both, of course, working to the same condenser-temperature.

The rectangle for the latter of these extends from the line of maximum entropy for the case assumed, *JK* in Fig. 7, down to the line *IM* through 46 deg. F., on the "total entropy curve," the end lines being drawn as before, the whole rectangle being *JKLM*.

The rectangle for the first-mentioned cylinder extends from the line *NLM* down to that of minimum entropy *GH*, the completed rectangle being *MNGH*.

The area of the first of these is  $3.50 \times 1.25 = 4.375$  square inches; of the latter  $5.60 \times 0.64 = 3.575$  square inches; total 7.95 square inches, corresponding to 7.95 horse-power per 75 lb. of air, as compared with 11.56 horse-power for doing the same work in one stage.

This involves also the great advantage that most of the water is removed at a temperature above freezing, so that the quantity of ice which can form is greatly reduced, even in the coils of the second stage.

Three stages could similarly be used, but with a much smaller saving, as an inspection of the area outside the "85 deg. horse-power curve" will show, so that the added complication of another stage would probably be a poor investment, especially as other considerations, to be mentioned presently, contribute to reduce the relative economy and desirability of this step.

The air leaving the refrigerator chamber is at the temperature of 25 deg. F., and it is plain on the briefest consideration that this may be used for cooling the incoming air, with a saving of power to the refrigerating machine.

What the amount of this cooling will be is, of course, not a question of entropy, but simply one of heat. It is not, however, one of easy algebraic solution, since the total heat of the vapor is a very complicated function of the temperature, that of the air being, of course, a perfectly simple one of direct proportion.

It is for this purpose that the curves of heat are added below those of entropy on the diagram.

The problem is: Given 75 lb. of dry\* air at 25 deg. F., allowing a temperature-difference of 10 deg. F., and using the counter-current system of cooling, to what temperature will 75 lb. of air at 85 deg., saturated with vapor at 70 deg. F., be cooled?

Neglecting the insignificant superheat of the vapor,

the air must be cooled from 85 deg. F. to 70 deg. F. before the moisture will be a factor, and the specific heat of air being constant this will obviously warm the dry air up from 25 deg. F. to 40 deg. F.

As 10 deg. F. difference of temperature to give the necessary thermal head is assumed, the dry air will be discharged at 75 deg. F., and the heat absorbed by it, from 40 deg. F. to 75 deg. F., is obviously that available for cooling the saturated air below 70 deg. F.

Taking from the curve "heat of dry air" that due to 35 deg. F. difference of temperature, we measure it off (towards the axis) from the 70 deg. F. point on the curve of total heat; it comes to 1992 British thermal units, the line through which intersects the total heat curve at 58 deg. F.

This transaction is shown by the lines *A'B'C'* in Fig. 7. From this it is obvious that the line of maximum entropy for this case is that through the temperature 58 deg. F., which is simply transferred vertically over to the total entropy curve. This line is shown at *VP* in Fig. 7, the whole rectangle being *VPHG*, whose area

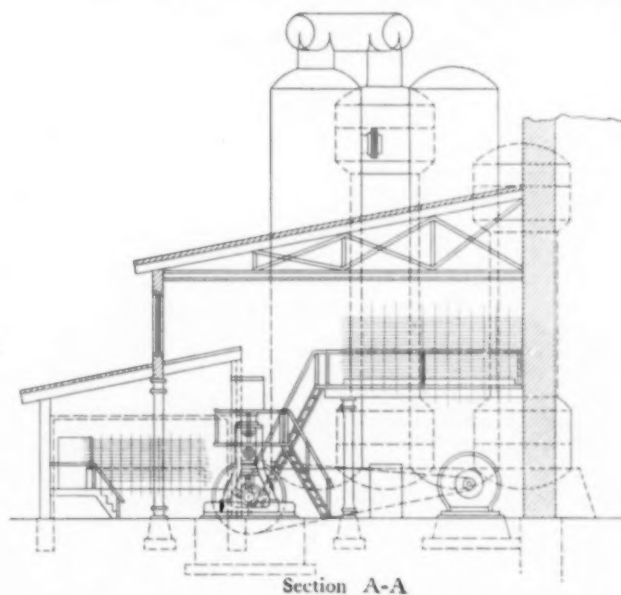


FIG. 8—ELEVATION OF CARRIER DRY-BLAST PLANT—(AMMONIA COMPRESSORS, MOTOR DRIVEN)

is  $1.11 \times 5.6 = 6.22$  square inches = 6.22 horse-power, as compared with 11.56 horse-power for the same work without regeneration.

With this improvement can now be combined that of stage refrigeration, by which is obtained the two rectangles *PQRS* and *TSHG*, whose areas are  $3.72 \times 0.66 = 2.45$  square inches, and  $5.6 \times 0.45 = 2.52$  square inches, corresponding to a total of 4.97 horse-power per 75 lb. air when refrigerated in stages and with the aid of regeneration.

From this it will be seen that great economies are effected by the use of the direct expansion system, by refrigerating in two stages and by regenerating the "cold" in the air which has passed through the system, for the purpose of cooling down the incoming air.

There is also another possibility in the direction of economy which received consideration in the original development of this process by Mr. Gayley and was brought out in the discussion of my paper, that is, the utilization of the reduction of the volume of the air due to its being compressed for delivery to the furnace. If the blast pressure is fifteen pounds obviously the volume of the blast at atmospheric temperature is reduced to fifty per cent of its original amount, and obviously also since the quantity of vapor present per cu.

\*The trivial amount of water vapor still present is neglected, being only 0.4 per cent. of the total weight.



ft. is a function of temperature only, this means that if the air were saturated before compression half the moisture would be squeezed out of it by compression, if its temperature were reduced to that of the atmosphere after leaving the blowing engine. This means plainly two things. First, less moisture to be condensed; second, the moisture present will be condensed to any desired limit with a higher dew point. This also means a saving in power.

In the early plants where the air was cooled by the introduction of vast masses of pipe coils into its path it was virtually impossible to have chambers which would withstand the blast pressure necessary, and of a size to contain this mass of coils without prohibitive expense and perhaps danger, therefore in these the refrigeration is always done before the air enters the blowing engine, but in later years the system of cooling the air by direct contact with a "rain" cooled by the refrigerating coils has been introduced and this eliminates the necessity for pipe coils in the refrigerating chambers, thus reducing the latter to relatively small dimensions, and this makes possible the use of the "post-compression" system of refrigeration.

This system has been worked out and applied by the

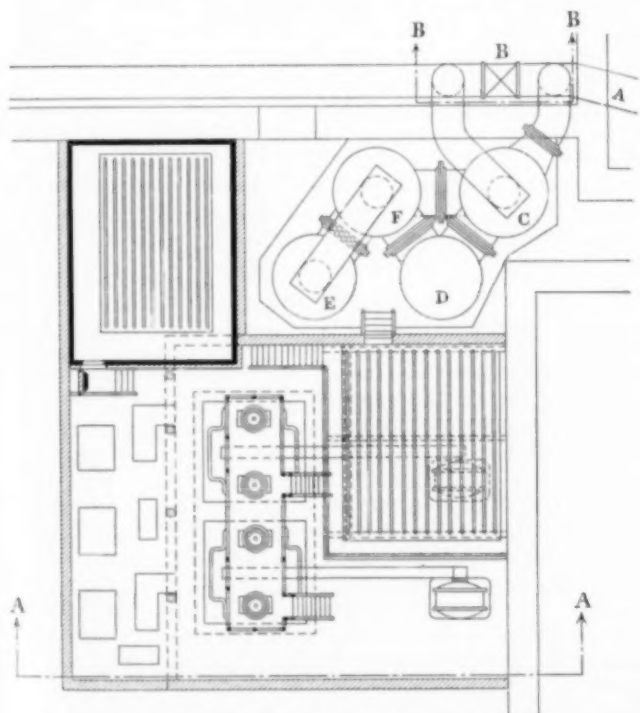


FIG. 9—PLAN OF CARRIER DRY BLAST

Carrier Air Conditioning Company of America, who also use regeneration and refrigeration in stages. A plant designed by them is shown by Figs. 8, 9 and 10. Fig. 8 shows a side elevation of the ammonia compressor (motor driven), and the ammonia condenser, also of the brine coolers, while behind, rising above the shed roof of the compressor house, are shown the outlines of the cooling chambers. Fig. 9 shows a plan of the same equipment. *C*, *D*, *E* and *F* are the various cooling chambers which can best be described by reference to Fig. 10, but before passing to this it is well to note that the cooling chambers are so arranged in reference to the blast main *A* that the blast can be thrown through them by closing the intermediate valve, or by closing the cut-off valves in the connecting necks and opening the intermediate valves, the cooling chambers can be cut off and the blast can go to the stoves direct, thus giving an opportunity to throw the

refrigerating plant out of service without shutting down the furnace.

Fig. 10 shows the coolers *C*, *D*, *E*, *F* as if they were arranged in a straight line so as to show the currents through them. *C* is a heat exchanger in which the cold outgoing air is warmed up almost to inlet temperature by the warm incoming air from the blowing engine. This accomplishes two good results. It sends the air warm to the stoves, and, much more important, it does a part of the cooling which would have otherwise to be done by more expensive means, i.e., direct refrigeration.

From *C* the blast passes into *D*, which is simply a spray tower supplied with natural cold water. This continues the refrigeration begun in *C*, and remembering that cooling water is generally available at or below the dew point of the air, and that the density of the air is approximately doubled by compression before entering this system, it is obvious that the temperature produced by such natural cooling water will precipitate much of the moisture. From *D* the air passes into the base of *E*, which like *C* is a heat exchanger. The cold air coming from the second spray tower presently to be described, and at the lowest temperature reached in the system, enters at the top of *E* as shown, while the incoming air to be refrigerated enters at the bottom, and passing in counter-current through the tubes of the exchanger is cooled to an important extent, while the outgoing blast is, so to speak, prewarmed for its entrance into *C*, because of course it is by-

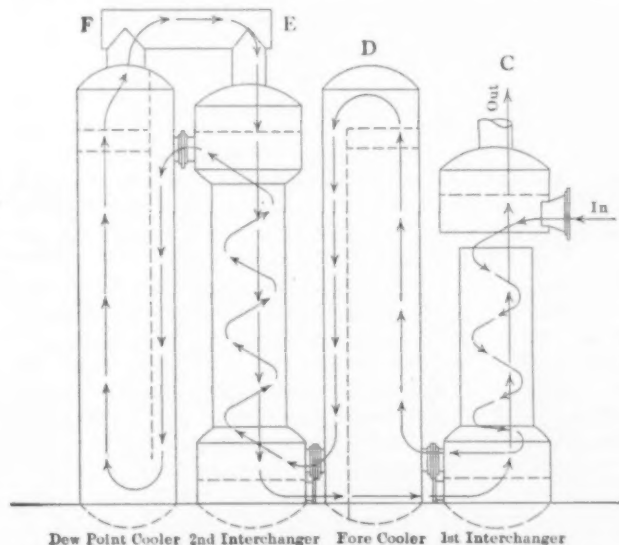


FIG. 10—DIAGRAM SHOWING ARRANGEMENT OF COOLING TOWERS AND REGENERATORS IN PROPER RELATION

passed around *D* and passes directly from *E* to *C*. From *E* the ingoing air enters the second spray tower *F* cooled with water refrigerated to a temperature between 32 and 40 deg. *F*. These spray towers have two great advantages. First, they avoid the use of expensive tubes for heat transmission. Second, they obtain immediate and practically unlimited contact with the air to be cooled so that the drop in temperature between the two is practically negligible. The incoming air therefore is reduced virtually to the temperature of the cold rain, or somewhere about 38 deg. *F*. From Fig. 5 it will be seen that at this temperature the moisture is .38 lb. per cubic foot; from this, remembering the compression of the air under which these conditions prevail, we find .19 lb. per cubic foot as the equivalent moisture in uncompressed air. This corresponds to a dew point of 22 deg., and is as low as it is economical to go in blast refrigeration.

One point of much importance is to be noted here. The temperature of the cold rain is well above the freezing point, while to secure a corresponding degree of refrigeration on the precompression system it is necessary to refrigerate well below the dew point, and this introduces all the complications caused by ice.

Both the pre-compression and post-compression systems have their advantages and their disadvantages. One of the principal merits claimed for the dry blast in its early days was that it produced a uniformity in conditions, in the quantity of air and the oxygen contained therein, delivered to the furnace per minute, and a considerable number of metallurgists attributed entirely to this fact the improvement in the operation of the furnace which it brought about. To the latter view I have never been able to subscribe. I shall later show what seemed to me conclusive reasons for believing that the great advantage of the dry blast lies in its dryness. At the same time the advantages of uniformity are not for a moment to be ignored. Now it is obvious that if the blast be reduced to a constant temperature, say to 25 deg. F., which was the practice at one time, nearly all the moisture as shown by Fig. 5 is removed from it, and the quantity remaining is made perfectly uniform while the temperature and therefore the density of the air are likewise rendered uniform. It then becomes necessary only to run the blowing engine at a constant speed to secure all the advantages of a constant weight of air per minute to the furnace. If a constant quantity of air be blown it is obvious that its volume after compression must vary from hour to hour and day to day on account of the varying pressure required by the blast furnace which produces a corresponding variation in the density of the air. Therefore if the quantity of moisture per cubic foot be kept the same by having an absolutely uniform temperature after refrigeration, the variation in the number of cubic feet due to the cause just explained still causes some variation in the actual quantity of moisture delivered to the furnace.

In recent years it has become the practice to change the speed of the blowing engine according to changes in the temperature of the inlet air to compensate for the corresponding variations in its absolute volume. So far no one has as yet introduced a compensation for variations in barometric pressure, though doubtless that refinement will come at some plants in time.

No difficulty is found in keeping constant the weight of air delivered to the furnace by this simple means. The Carrier Air Conditioning Company have applied the same idea to securing a constant quantity of moisture in the blast irrespective of the blast pressure, regulating the dew point by means of changes in the temperatures of the refrigerating apparatus; they have also developed a mechanism whereby this change is automatically made, thus securing a constant weight of moisture with varying blast pressure.

Another respect in which the pre-compression and the post-compression system differ is that with the former all the air is delivered to the blowing engine cold, and the reduction in volume resulting from this causes proportional reduction of the power required by the main blowing engine. On the other hand the refrigeration expended upon the air at a considerable expense, is lost except for this saving. Now it can easily be proven by thermo-dynamics that if both the refrigerating machine and the blowing engine were perfect the total power required to refrigerate the air down to any desired temperature, and then compress it from that low temperature, would be exactly the same as the power required to compress it directly from atmospheric temperature. It becomes therefore a question as to which machine is

the most efficient, a question easy to decide, for we know that good blowing engines are from 85 to 90 per cent efficient, while even good refrigerating plants are only around 55 per cent. It is obvious, therefore, that it pays to save power in the refrigerating machine even at the expense of the blowing engine. But another point is to be considered here. When the pre-compression system is used the blast containing much of the heat of compression passes at once to the stoves and of course reduces the amount of heat to be imparted by the stoves proportionately, whereas the post-compression system if applied the same as the original pre-compression systems would deliver strongly refrigerated air to the stoves with corresponding increase in the heat required of them.

It is partly to overcome this disadvantage that the Carrier Company uses the first exchanger shown in their system since by the aid of this they can warm up the outgoing air within a few degrees of the temperature of the incoming air. This puts matters on practically an even basis as regards the heat to be supplied by the stoves.

Using the post-compression system permits giving paramount consideration to the power requirements, and these, as has been pointed out, are greatly reduced by the use of exchangers and the two-stage system. They are also further reduced by the fact that the temperature to which the air must be refrigerated is not nearly so low as under the pre-compression system to reduce the moisture to the same number of pounds per minute. This has a very decided bearing on the power requirements, since it has been shown (see article in *Metallurgical and Chemical Engineering*, December, 1912, above mentioned) that the power required for any given quantity of refrigeration ( $Q$ ) is

$$HP = 0.0235Q(Z + 3.7Z')$$

in which  $Z$  is equal to  $\frac{T_1 - T_2}{T_1}$  and this is obviously less as the temperature to which we refrigerate is raised. Moreover, while the quantity of refrigeration for the condensation of the moisture is the same, that for the cooling of the air is less, because the temperature to which the given weight of air is cooled is not so low in the post-compression system as in the other, it is therefore obvious that the power required must be very materially less with this system than with pre-compression.

A considerable advantage in the use of exchangers inheres in the post-compression system for the reason that the greater density of the air greatly increases the ease with which heat may be imparted to or abstracted from it, and the exchangers can therefore be smaller on this system than they could for an equal degree of efficiency if used on the pre-compression system.

The slightly lowered temperature at which the air is delivered to the stoves constitutes the principal objection to this system when the blast furnace pressure is twelve pounds or more, but when the pressure is less than this the reduction in volume of the air is very much smaller, and the advantage of the system falls off proportionately, so that there may be cases in which it is desirable to use the pre-compression system, but in such cases there is no excuse for not using two-stage cooling and regeneration.

It may be thought that the cost of the regenerator is just that much addition to the total cost, but this is by no means the case. The regenerator does, without consuming any energy, a part of the refrigeration which would otherwise have to be done by the refrigerating machine, and therefore makes a proportionate reduction in the size of refrigerating equipment required, whose cost per unit of work done is of course very much greater than the cost of the regenerator.



By the use of the rain system two great advantages are obtained. First: The avoidance of the heavy cost for brine circulating coils and the chambers in which to enclose them. Second: The avoidance of the additional drop of temperature required to force the heat from the air into the brine through pipe walls which involves a lower temperature of refrigeration for a given degree of moisture removal. The whole plant is made smaller and more compact and in every way cheaper and better by this system.

If rain be used for carrying the heat from the refrigerating coils to the air, as is most desirable, it becomes necessary to use a non-freezing solution for this purpose if the second stage of the refrigeration takes the temperature below the freezing point as a pre-compression system should probably do. For this purpose brine, preferably made with calcium chloride, should be used, and as this obviously takes up most, if not all of the moisture from the air which it cools, an evaporator must be arranged at some point in the circuit to remove the accumulated water from the system and maintain the strength of the brine. In such a case a heat exchanger should be installed between the refrigerating system and the evaporator so that the "cold" in the incoming and the heat in the outgoing brine may both be conserved.

(To be concluded in August issue)

## The Relative Migration Velocities of the Ions in Complex Electrolytes

BY A. MUTSCHELLER

In a former paper on "The Action of Certain Colloids on Ions During Electrolysis," the author has given experimental data which are in support of a theory explaining the function of certain colloids when added to a heavy-metal electrolyte for the purpose of obtaining a smooth and consistent metal deposit on the cathode. The discussion relates to the change of velocity of the ions which take part in the electrolysis, which change is brought about by the addition of a certain quantity of certain colloids to the electrolytic bath.

It is shown in that paper that certain reversible colloids, as for example, gelatine, gum arabic, soluble starch, etc., exert a neutralizing action on one of the ions, thereby rendering it unsuceptible to the force of the electric field across the bath so that the other ion is left alone active in the electrolyte. This formation of an electrically neutral complex is due to the so-called protective action of the colloid added and consists in the formation of absorption compounds, the colloid which carried an electric charge having combined with the ions of opposite charge, which are in this case the anions.

The removal of one ion by the oppositely charged colloid causes the ionization of the unionized part of the salt in solution to continue until the ionization constant is again satisfied. Under these conditions, therefore, the free ions, i.e., those left in the solution, are the sole ionic constituent of the electrolyte, hence the flow of electric current through the bath is effected through the transport of electricity from the anode to the cathode by the remaining cations in case the colloid was positively charged and was, by virtue of this charge, absorbed by the anions. This, then, it was found, is the condition of successful deposition of metals, for, as long as the concentration of the cations is being maintained constant around the cathode, no formation of trees or loose and brittle deposit is taking place.

Since it is well known that the charge carried by a particle of a colloid is not that of one electron but

ordinarily an indeterminate multiple thereof, it is necessary to find by experiment the right amount of colloid, or rather the right amount of electric charge on the colloid, that must be added to the electrolyte in order to just balance the electric charge of the anions. It has been shown in the above mentioned paper that, if there is an excess of positively charged colloid, the absorption complex is positive and will migrate to the cathode and deposit there, i.e., the anions are actually carried to the cathode. If, however, on the contrary, there is a deficiency of positively charged colloid, the negative character of the charge of the anions will prevail and the complex of colloid and anions will migrate to the anode.

While the above-named paper was in preparation, the experimental part of the present communication was in progress. Moreover, the conclusions of the first paper could not be accepted as general principles if they did not apply to the case of the complex electrolytes which are used in practical work for the reason that they also give smooth and compact deposits.

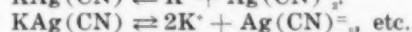
Collections of the formulæ of various solutions that have been proposed for the electrodeposition of the more common metals consist characteristically of complex solutions of cyanide or ammonia salts of the metal to be deposited or potassium cyanide or some ammonium salt is mixed with the electrolyte. A few "plating solutions" have been selected as typically representative of these classes, and in the following is given a discussion, together with the results of an experimental investigation, on the relative velocities of migration of the ions involved in the process.

### The Silver-Cyanide Plating Solution

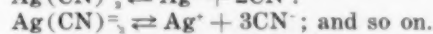
According to Bodländer<sup>1</sup> silver forms a series of complex ions with potassium cyanide, the composition of which depends on the relative quantity of cyanide present in the solution. The formation of the first salt takes place according to the following equation:

$\text{AgNO}_3 + 2\text{KCN} = \text{KAg}(\text{CN})_2 + \text{KNO}_3$ . The next salt which forms with a greater excess of cyanide is

$\text{AgNO}_3 + 3\text{KCN} = \text{K}_2\text{Ag}(\text{CN})_3 + \dots$  and so on for the higher salts. If these salts are submitted to electrolysis, using inert electrodes, it is found that the silver does not migrate to the cathode but instead goes to the anode, whence silver must be a component of the anion. This complex anion has been formed then by the combination of a positive silver cation with two negative cyanide anions which produce the monovalent negative argento-cyanide ion  $\text{Ag}(\text{CN})_2^-$ , or the divalent ion  $\text{Ag}(\text{CN})_3^{=}$ , etc. These ions themselves, however, are not completely stable; they in turn dissociate, satisfying a certain equilibrium constant. Hence, for the dissociation or splitting up of these complex ions we have the relation



Moreover, as these complex ions are not absolutely stable, a further ionization takes place according to the following scheme



$$\text{Or } [\text{Ag}^+] \times [\text{CN}^-]^2 = [\text{Ag}(\text{CN})_2^-] \times k_1$$

$$[\text{Ag}^+] \times [\text{CN}^-]^3 = [\text{Ag}(\text{CN})_3^{=}] \times k_2, \text{ etc.}$$

Bodländer determined these constants and found  $k_1$  equal to  $8.8 \cdot 10^{-22}$  and  $k_2$  to  $1.13 \cdot 10^{-23}$ .

The instability of these ions is probably considerably

<sup>1</sup>Trans. Am. Electrochem. Soc., vol. 23, 17-26 (1913).

Watts, Lab. course of El. Chem. pp. 72-83.

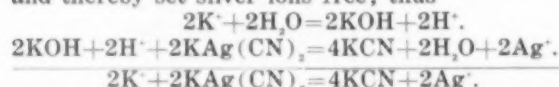
<sup>2</sup>Zeit. f. anorg. Chem., 39, 196 (1904).

The acid  $\text{HAg}(\text{CN})_2$  is crystallizable and is found to be a strong acid. Its potassium salt  $\text{KAg}(\text{CN})_2$  is, therefore, also highly ionized. (Stiglitz, Qual. Anal.).

<sup>3</sup>This journal, June, 1915.

increased while the complex ion migrates to the anode. The residual positive charge of the silver ions bound in the complex ions enters more and more into the region of the repelling positive force of the anode while the attractive force on the negative cyanide ions due to the same electric force increases at the same rate. The cyanide anions, therefore, are attracted toward the anode whereas the silver cations are repelled toward the cathode. With the products of this ionization thus rapidly removed, even the very small degree of dissociation is sufficient to furnish a sufficiently abundant number of silver ions which are to be deposited. The cyanide anions, in case that a silver anode was used, forms the argento-cyanide<sup>5</sup> salt of silver ( $\text{AgAg}(\text{CN})_2$ ). This salt then immediately breaks up again as above outlined and the silver ions migrate to the cathode in order to be deposited there.

Again, there being potassium ions present from the first ionization, we must naturally expect them to appear at the cathode where the potassium formed acts on the water and forms the hydroxide and hydrogen gas. These products act on the complex cyanide salt present and thereby set silver ions free; thus



It is to be observed at this point that potassium does not deposit, but only frees the silver ions, and those require for their own deposition new electrical energy, hence the equivalent of silver ions that originate at the anode are not deposited at the cathode and so we should expect an increase of silver at the cathode side of the bath. If, again, this increase actually occurs, this would be an equally sure indication that the dissociation of the complex salt does not take place throughout the bath but at the anode only and thus it would become evident that the cyanide ions do not at all take part in the migration or transport of electricity across the bath.

In order to fully investigate this question, the following series of experiments have been performed.

#### EXPERIMENTAL PART.

The formulæ generally recommended for the silver plating solution differ considerably in the quantity of free potassium cyanide that should be present in the solution. The solution used for the present purpose was prepared by precipitating silver nitrate with potassium cyanide and washing this precipitate by decantation. It was then redissolved by further addition of potassium cyanide solution employing care to make the excess very

small. The excess was tested by adding — silver nitrate solution to 10 cc. of the prepared solution. About 0.7 cc. were required to cause a permanent precipitate. The chemicals used were of c.p. quality.

This solution was introduced into the H-shaped migration tube described in the former paper and platinum was used as cathode but pure silver wire as anode. The silver in the original solution and the silver in the solution of the cathode compartment after various times of run was determined by electrolysis with a platinum dish as cathode and a heavy platinum foil as anode. The deposited silver was pure white after washing, drying and slight heating.

In table I the increase of silver in the cathode compartment is given for various amounts of silver deposited on the cathode in runs from  $\frac{1}{2}$  to 3 hours. The concentration of the electrolyte was 5  $\text{KAg}(\text{CN})_2$  to 100 water, with a slight excess of KCN.

<sup>5</sup>Bodländer shows that silver forms ions of this type more readily and completely than  $(\text{AgCN})_2$ . *Zeit. f. anorg. Ch.*, 39, 196 (1904).

TABLE I

Experiment No.	Amount of Silver Deposited on Cathode	Silver Migrated Toward Cathode	Increase of Silver in Cathode Compartment
1	0.0147 gr.	0.0228 gr.	0.0082 gr.
2	0.0234 "	0.0363 "	0.0129 "
3	0.0652 "	0.0984 "	0.0332 "
4	0.0761 "	0.1152 "	0.0391 "

It follows, therefore, from the experimental determinations that there is actually an increase of silver found on the cathode side of the plating bath. The silver ions are the only carriers of electricity across the solution and the single anions (the  $\text{CN}^-$  ions) do not participate in the transportation of electricity such as they do in non-complex-ion electrolytes and in the absence of certain colloids such as described in the first publication.

#### The Nickel- and Zinc-Ammonia-Sulphate Plating Solution

The electrolytic baths generally recommended for the deposition of the metals nickel and zinc consist almost exclusively of an aqueous solution of a salt of the metal and an ammonium salt or the metal-ammonium double salt. In some cases other additions are made; for example, more ionized salts are added to decrease the resistance of the bath (such as  $\text{ZnCl}_2$  to the zinc plating solution). Other additions such as sulphides, thiosulphates, hyposulphites, etc., are made for the purpose of

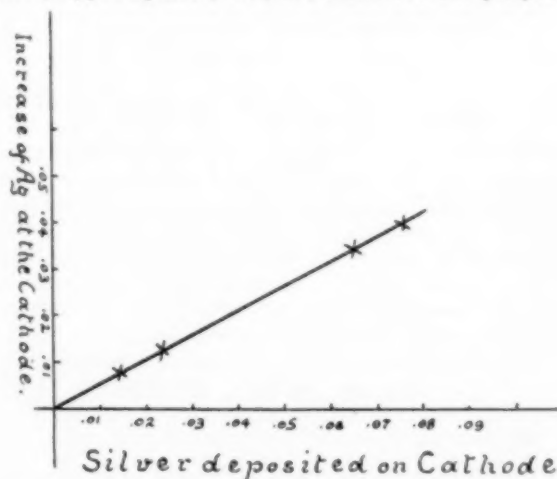
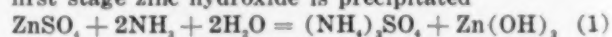


FIG. 1—SHOWING THE GRADUALLY INCREASING SILVER CONCENTRATION IN THE CATHODE COMPARTMENT

influencing and changing the color of the deposit. Their functions are secondary and their presence has no bearing on the general form and quality of the deposit.

In view of the fact that all these metal ions enter into the formation of complex ions, it would appear that, if the relation of their ionic migration velocity should turn out to be approximately the same as that in the silver-cyanide salt, the same working principle would apply for the complex metal-ammonia ions. Assuming for an instant that all these conditions do hold, it must be remembered that cyanogen with silver forms a complex anion, whereas ammonia with metals forms complex cations. The mechanism of the working of these ions must, therefore, be different from that of the silver-cyanide ions.

When ammonia is gradually added to a solution of a zinc salt the following changes probably occur: In the first stage zinc hydroxide is precipitated

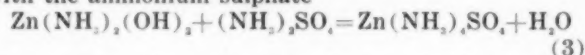


The zinc hydroxide then dissolves in an excess of ammonia with the formation of a soluble base

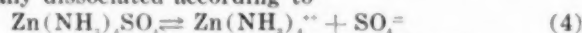
<sup>6</sup>Abstr. Chem. Zentralblatt, 11, 265 (1900).



$\text{Zn}(\text{OH})_2 + 2\text{NH}_3 = \text{Zn}(\text{NH}_3)_2(\text{OH})_2$  (2)  
the complex zinc-ammonia base probably reacts further with the ammonium sulphate



The complex zinc-ammonia salt is probably electrolytically dissociated according to

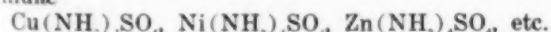


Konowaloff<sup>2</sup> determined the partial pressure of ammonia in ammoniacal salt solutions by drawing a current of air through the solutions contained in a thermostat at 60° C. into a standard acid solution. He finds that the partial pressure of the ammonia of the salt solutions is expressed by the formula

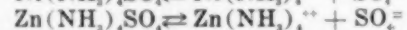
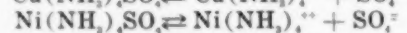
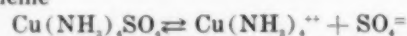
$P = P_1(n - km)$ , . . where  $P_1$  is the partial pressure of ammonia from pure aqueous ammonia solutions,  $n$  is the number of grammoles of ammonia and  $m$  the number of grammoles of salt per liter;  $k$  is a constant. For silver nitrate he finds  $k = 2$ ; for zinc nitrate, nickel chloride, copper and cadmium nitrate, etc.,  $k$  is approximately 4 (3.4 to 4.04). In the case of some other solutions which are not precipitated by ammonia and afterwards redissolved he found the partial pressure of ammonia in such ammoniacal solutions to be greater than in pure aqueous ammonia solutions (except in the case of calcium and strontium chloride). Hence, the compounds existing between the salt and ammonia are of the type  $\text{M}(\text{NH}_3)_x\text{SO}_4$  or for nickel and zinc  $\text{Ni}(\text{NH}_3)_4\text{SO}_4$  and  $\text{Zn}(\text{NH}_3)_4\text{SO}_4$ .

Dawson and McCrae<sup>3</sup> applied the law of distribution (Nernst), according to which the condition of equilibrium at a given temperature is determined by a constant ratio of the concentrations in the two immiscible solvents, if the molecular weight of the distributed substance is the same in the two media. In other words, this constant or coefficient of partition of a substance between two solution media indicates any change which took place in the molecular configuration when the substance entered the other medium. (Hantsch and Seibaldt.<sup>4</sup>) The deviation of the distribution coefficient for the salt solution from the value found for pure water and a non-miscible medium will measure the complexity of the compound. As such molecular changes probably occur in some ammoniacal salt solutions, the investigation of the distribution coefficient of ammonia between such salt solutions and a medium non-miscible with water will indicate the formation of any complex compounds produced by the combination of the salt and ammonia.

The results of these investigations indicate that in a certain number of solutions investigated in presence of a considerable excess of ammonia one molecule of the salt takes up four molecules of ammonia, and that this ammonia can no longer act as free ammonia and enter into the establishment of the equilibrium between the aqueous medium and chloroform. The ratio obtained suggests the existence of compounds of the formulæ

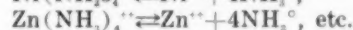
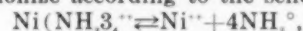


If we now assume that these salts ionize according to the scheme



we should expect that the addition of sodium sulphate would have an influence on the equilibrium between the copper salt and ammonia. This, however, is not the case, for experiment shows that the addition of sodium sulphate has no influence on the equilibrium, the proportion of combined ammonia remaining the same.

The further dissociation of the resulting complex ions has also been investigated and it was found that they also ionize according to the scheme



Euler<sup>5</sup> determined the constant of dissociation for the zinc-ammonia ion

$$[\text{Zn}^{++}][\text{NH}_3^0]^4 = [\text{Zn}(\text{NH}_3)_4^{++}] \times 2.6 \cdot 10^{-10}$$

Ammonia originating from this dissociation is not an ion, but ammonia in the elementary state. As such it diffuses rapidly into the solution and as the investigations of Konowaloff and Dawson and McCrae show, it forms the complex ammonia-metal ions with the zinc or nickel salt in the solution.

Leaving for the present the question undecided, whether the  $\text{Cu}^{++}$ ,  $\text{Zn}^{++}$ , or  $\text{Ni}^{++}$  exist as single or complex ammonia ions in the solutions which are recommended as electrolytes, there can be no doubt that the metal ions and the ammonium ion together migrate to the cathode. That ammonium, after being liberated, forms ammonia, and as such interreacts with the metal ions present to form the complex ions follows from the above mentioned investigations. Hence, this case is of the same mechanism as the silver-cyanide equilibrium. That is, the complex ammonia ion forms an intermediate product which dissociates in turn, forming with the anions a salt by means of which the anions are withdrawn from the function of transporting electricity from one electrode to the other.

From this hypothesis it must again be concluded that the cations alone transport electricity, so that the full equivalent of metal that is deposited must migrate toward the cathode. If, then, the ratio between the metal and the ammonium salt are properly balanced, there should be no decrease of concentration of the metal ions in the fluid of the cathode compartment during the run.

This investigation was carried out and the results together with a description of the methods of procedure are given in the following:

#### EXPERIMENTAL PART.

The determination of the relative migration velocities of the ions of the zinc and nickel plating solutions was carried out in the manner already described. The anodes were sheets of zinc and nickel respectively, and the quantitative determinations of the metals in the solutions were made by electrolytic analysis, using platinum as anode and a platinum dish as cathode. The solutions used were of the following composition:

The nickel plating solution contained  $\text{Ni}(\text{NH}_3)_4(\text{SO}_4)_2$ , 46 grams per liter of solution, and 5 drops  $\text{H}_2\text{SO}_4$ .

The zinc plating solution had the following composition:  $\text{ZnSO}_4$ —50 gr,  $(\text{NH}_4)_2\text{SO}_4$ —10 gr,  $\text{ZnCl}_2$ —2.5 gr, water—250 cc. The migration ratios were found such as given in the following tables:

TABLE II

Experiment No.	Amount of Nickel Deposited on Cathode	Nickel Migrated Toward Cathode	Decrease of Nickel in Cathode Compartment
5	0.0966 gr.	0.0870 gr.	0.0096 gr.

TABLE III

Experiment No.	Amount of Zinc Deposited on Cathode	Zinc Migrated Toward Cathode	Decrease of Zinc in Cathode Compartment
6	0.1507 gr.	0.1496 gr.	0.0011 gr.

As will be seen from these tables, there is a slight decrease of the concentration of the metal ions in the

<sup>1</sup>J. Chem. Soc. 77, 1239, (1900).

<sup>2</sup>Zeit. phys. Chem. 30, 258, (1899).

<sup>3</sup>Ber. d. chem. Ges., 36, 3403, (1903).

cathode compartment. It is to be recalled, however, that the electrolysis starts with a liberation of ammonium at the cathode. At the anode we must naturally have the corresponding equivalent of sulphate ions appear. Probably the liberation of ammonium and subsequent formation of ammonia causes the formation of the complex ammonia-metal ion, hence, while the first complex ions are being formed at the cathode, there are some anions migrating and this then reduces the migration velocity of the cations to a value slightly less than one. Moreover, in the case of the argento-cyanide electrolyte the case is just reversed, for there the complex ions are already formed, but as the potassium salt which later changes into the silver salt. In case of a complex anion, there is a slight increase of metal in the cathode compartment, but in case of complex cations there is a slight loss and this fact is brought out by the results given in the tables.

### Conclusion

Although Faraday's law is sometimes stated in the form that if a certain quantity of electricity passes across the solution of an electrolyte, there will be deposited the corresponding electrochemical equivalent of metal on the cathode, this statement of it is inadequate and does not include that the principle can be employed technically with success without further provisions as a process for the deposition of metal upon objects by simply making them the cathode in the electrolytic bath. The technical man says that in most cases the deposit does "not stick"; in other words, the metal deposit lacks certain qualities such as smoothness, purity, and consistency, which are indispensable for the successful technical utilization of the electrodeposition of metals.

In a former paper<sup>10</sup> the writer of this article has reported experiments which show that the addition of certain colloids, at the same rate as it improves the qualities of the deposit, influences the ionic migration velocities of the ions. The relative velocity of the cations is increased nearly to unity and that of the anions is decreased nearly to zero, while the quality of the deposit improves.

In the present paper an attempt is made to demonstrate that the same principle applies to the formulae which are used as electrolytes for the deposition of the more common metals. There is agreement of the results, since all the solutions investigated, which give more or less smooth deposits on the cathode, have the relative velocity of migration of the ions altered in the way that the velocity of migration of the cations comes nearly to unity and the anions cease to take part in the migration so that their velocity is lowered to near zero velocity.

It appears, therefore, justifiable to state that the condition under which good deposits of metals are obtained is that the concentration of the metal ions at the cathode must remain constant during the deposition. This condition can only be obtained by excluding all ions ordinarily migrating toward the anode from the function of transporting electricity, so that the cations must migrate toward the cathode as fast as they deposit there. We have observed that if this condition is fulfilled there will be obtained the optimum of quality of the deposit.

Finally, it has been shown that this effect on the migration velocity of the ions can be exerted (1) by making the proper addition of positively charged colloid to the electrolyte, whereby the anions are absorbed and electrically neutralized, hence cease to migrate, or

(2) either by composing the electrolyte of such complex ions whose products of dissociation re-engage the anions into a non-ionized or little ionized salt, leaving only the cations intact; or by using additions of such salts, which, as the electrolysis proceeds, form complex ions, the products of dissociation of which combine into non-ionized or little ionized salts with the anions, thus leaving the cations free and intact.

Chemical Laboratory, Pathological Department,  
German Hospital and Dispensary,  
New York.

### Good Advice to Consulting Metallurgists and Others

In a paper published by Mr. W. B. Blythe in the *Proceedings* of the Australasian Institute of Mining Engineers, the author closes with some counsel to consulting metallurgists which is particularly appropriate for young engineers, and perhaps some older ones. We quote the following:

When everything is running well and smoothly, and good profits are being made, there is no cause for worry; but with the turn of the tide of prosperity a reverse current generates doubt and uneasiness, and, among other things, a metallurgical examination is demanded. There is no finer test for genuine metallurgical ability and common-sense than these plant investigations. The operation calls for the exercise of skill, tact, diplomacy, patience, and analytical reasoning of the highest order over an extended period.

There is a tremendous inducement to rush in "where angels fear to tread" and condemn everything offhand as being antiquated, and insist on modernizing the whole scheme of operations. This inclination must be held firmly in check. Always remember that the man you superseded had brains, and that his length of service on the mine (if no other reason) renders his advice and recommendations of value. You will probably see anomalies staring you in the face at every corner. After you have been on the mine for some weeks you will find that most of them are not anomalies, but are real necessities under the existing circumstances. Never run down that predecessor of yours; the inclination to do so is strong at the beginning, but your respect for him increases later on.

When you make changes in the circuit of an old plant of an experimental nature, always, wherever possible, leave a loop-hole to get back to the old circuit. A sudden change usually upsets the equilibrium at some unforeseen point, and unless precautions are taken a heavy loss will occur before these subordinate factors are straightened out. Start your investigations at the residue end of the plant—this is the most important, as an indicator of efficiency or otherwise; work back gradually to the mill; and do not hurry. Start by checking the results being obtained at the time of your arrival, and accept these as the basis of your recommendations. Do not accept for granted any previous figures as to extraction or tonnage.

Get your assays prepared by your assistant, and assayed by an independent operator. If they do not agree with the mine results, look for the reason. You will probably find that the error has crept in during the preparation of the samples for assay. Anyone can obtain a reliable result from a powdered sample, but it requires careful and conscientious labor to ensure that that ground sample is strictly representative of the original large bulk sample. The assayer is usually a conscientious, trained worker, who, under the stress of heavy routine duties, has not the time to superintend thoroughly the preparation of his samples—often this work is outside his province.

<sup>10</sup>loc. cit.



Keep all your assay results, and ideas generally, to yourself for the first week or two, and encourage the foreman to talk and advise you what to do. They probably all know more than you do at this stage, and they think more of you if you listen to them than if you adopt a bombastic attitude and start to lay down the law. Gradually introduce a few small improvements—if possible, some that the plant men have suggested first. They will work with you heart and soul to make these a success, and the personal element is an important factor in metallurgical operations. Clean the plant up, and the men will take a pride in keeping it clean, and in their work generally.

An eminent mining engineer once went to West Africa to report on some properties, and instead of starting in his report to discuss rises and winzes and the usual profit-making consideration, he launched off on to a technical dissertation on the mosquito. Well, the mosquito is a big factor in West African finance; so also are filthy conditions and general untidiness in the ordinary plant work. Dirty plants and low residues do not co-exist, but, unfortunately, the reverse does not always apply.

Improving plant conditions is a slow and tedious operation, but it must not be rushed. The investigator usually meets with silent and carefully veiled antagonism, and this must be overcome. The easiest way to overcome it is to improve the workmen's conditions, and these begin to improve from the commencement of the general plant clean-up.

The penny-wise-pound-foolish type of manager cuts down the number of hands until no cleaning or repair work is done at all. Temporarily reduced labor costs follow, but not for long; the increased losses and breakages resulting from this policy soon overshadow the saving in this direction.

Give the leading plant men, to a certain extent, your confidence, and show them the results of their work. There is no gain in the profound secrecy policy of some managements. It reminds one rather of the dark chamber of the alchemist and its veiled mysteries. Thrust on the leading men's shoulders a little responsibility; it pleases them and relieves your own, and they take an increased interest in their work.

Do not do any manual labor yourself, and remember that each man around the works can do his own particular duties a little better than you can, although at times you do not think so. When they seem slow, remember that they are not paid so much as you are. You are paid for your brains, and if you want to use them to the greatest advantage for your company you must not get physically tired. Always make out that things are quite as bad as they really are, and if you can improve them you will get due kudos. But if you are unable to realize your original reported anticipation you will meet with scant consideration. Never boast of your knowledge or achievements, as, excepting perhaps golf, the writer knows of no scientific pursuit where the boaster is so liable to be "hoisted with his own petard" as the searcher after the truth in the fields of metallurgy.

**Lead Poisoning in Manufacture of Storage Batteries** is the subject of Bulletin 16S of the Bureau of Labor Statistics of the Department of Labor. The author is Dr. Alice Hamilton. It is thought that the dangers of the industry can be reduced to a minimum by installing hoods and exhausts to carry off fumes and dusts by substituting machine for hood work, by providing ample washing facilities for the workmen and insisting on strict cleanliness everywhere and by providing a separate lunch room as the only place where food may be kept and eaten.

## Metallurgical and Chemical Engineering in Great Britain

(From our London correspondent.)

### Recent Progress in Pyrometry

Mr. C. R. Darling's paper with this title, read before the Royal Society of Arts on May 12—Sir Robert Hadfield presiding—almost synchronized with the Iron and Steel Institute meetings. It was both useful and interesting—particularly so with reference to the "ageing" of the thermo-couples of thermo-electric pyrometers, and to the protecting sheaths necessary to shield junctions from the corrosive action of furnace gases. Alundum, silfrax and silit were dismissed as not wholly suitable, the two first named owing to their being permeable to gases at high temperatures, and all three because of brittleness. A new type of sheath for use with molten brass or bronze, possessing a tip of molybdenum connected to a nickel tube covered with a protecting material was mentioned as being said to be satisfactory.

The use of resistance pyrometers at high temperatures was remarked as depending upon a protecting sheath capable of withstanding temperatures of 1400 deg. C. and over. Given the requisite material the author indicated that alundum would form a suitable resistance material.

Radial and optical pyrometers were explained and an excellent exhibition of typical pyrometers attracted attention at the end of the meeting. Before this, however, the discussion on the paper, opened by the chairman, was concerned with the importance of accurate measurements of temperature, and the citation of instances of the great changes in physical properties occasioned by small temperature differences. Sir Robert expressed his own preference for platinum and platinum-rhodium couples.

Dr. Harker of the National Physical Laboratory and Mr. H. C. Jenkins also spoke.

### The Scottish Kelp Industry

A leaflet issued by the Board of Agriculture for Scotland says the kelp industry has improved in the last five years, and it would pay crofters and others in districts where the right kind of seaweed is found on the shore. Up to about seventy years ago kelp was made for the soda which was obtained from it. Other and cheaper ways of getting soda were found out, and the price of kelp became lower and lower, so that in many districts the people gave up the making of it. Soon afterward iodine and potassium began to be extracted from kelp and the price rose slightly. There were ups and downs but on the whole the value increased. From 1907 to the early part of 1914 this rise in value became marked.

Potash has been obtained almost entirely from Germany where there are mines of it. Consequently, as long as the war lasts, the only important available source of potash will be kelp and hence the price of kelp has increased since the war. The consumption of potash is very great. It is the main constituent of several important artificial manures, besides being largely used in manufactures. Also, since iodine is in growing demand in military surgery, its value, too, is likely to become higher; though even during the war the increase is not likely to be so great as in the case of potash because iodine is obtained from the nitrate fields in Chile as well as from kelp.

Just before the war it may be estimated that the price which the workers might expect to receive for 1 ton of kelp was £5 to £5 10s. It is probable that this season at least £1 more per ton may be obtained. To secure this sum the worker will have to gather the proper weed, to dry it and then burn it. It requires about 5 tons of dry weed to make 1 ton of kelp.

### International Commerce

There will be some startling national trade balance sheets when once the war ends. One does not only refer to casualty lists, national indebtedness or property destroyed. There is, too, the cost of the industrial dislocation inseparable from the diversion of labor from the loom to the trench and the exchange of the plough for the machine gun. Some indication of this is given in some recently published statistics of the external trade of France. In these imports and exports for the first five months of the war are compared with the imports and exports for the similar months in the preceding year. The net result is that imports fell to 59.5 per cent and exports to 66.5 per cent of their previous value.

### Research Work by the Institution of Mechanical Engineers

According to the annual report of the Council of the Institution of Mechanical Engineers, the Alloys Research Committee has continued its work and the eleventh report will be ready this year. The results of research at Sheffield on chemical and mechanical relations of iron, tungsten and carbon, and iron, nickel and carbon were presented in the form of a paper during the year. This work is being continued in connection with the carbides of cobalt and molybdenum. A paper on the former will shortly be presented. The Refrigeration Research Committee has presented its first report and is now conducting experimental work. The Wire Ropes Research Committee has collected a large amount of data and hopes soon to carry out tests. A committee is investigating the action of steam passing through nozzles and steam turbines, and the Brush Electrical Engineering Company has lent a three-flow condenser for the purpose. A research committee is investigating the question of a hardness test for hardened journals and pins. An advisory committee has been appointed to prepare a scheme for the co-ordination of research.

### The Estimation of High Temperatures by the Method of Color Identity

Messrs. Paterson and Dudding's paper published in the April issue of the Proceedings of the Physical Society of London is modestly described by the authors as a preliminary note. Yet it is no idle praise to state that the paper represents original work of a very high order. Covering as it does some thirty printed pages abstraction is not easy. The general contents are best indicated by the following extracts of the authors' synopsis:

1. Preliminary experiments are described on the method of "color identity" adapted to the estimation of the temperature of incandescent substances such as metal or carbon radiating in the open: by this method the "true" temperature of certain bodies as distinct from their "black-body" temperature can be arrived at with a very fair degree of accuracy.

2. By the color identity method the total luminous radiation (white light) from a black body is made identical in color with that from the incandescent metal under examination by adjusting the temperature of the black body until there is color identity in the field of a Lummer-Brodhun photometer.

3. Comparisons are made of the results so obtained with those obtained by other methods and the color identity method is shown to give the correct result for melting platinum.

4. An explanation is given of the principal factors and limitations of the color identity method in which it is shown that accurate results should be obtained so

long as the bodies under consideration act as "grey" bodies throughout the visible spectrum and that there will be a tendency to error to the extent that they depart from the grey body condition in the visible spectrum.

### Laboratory Glassware

A most invaluable piece of investigatory work of great and immediate industrial value forms the subject of a short report just issued by the Council of the Institute of Chemistry. This summarizes the work of the Glass Research Committee appointed last October to conduct investigations with a view to arriving at suitable formulæ for the use of manufacturers willing to assist in maintaining the continued supply of laboratory glassware.

The chief aims of the research have been: (1) To produce working formulas for all glasses used in laboratory work, and (2) to ascertain the influence of various ingredients on the physical and chemical properties of glasses. The work was extended to include glasses for miners' lamps following the suggestion of the Home Office; and also glass for ampoules, to meet the needs of wholesale pharmaceutical chemists engaged in the production of army medical products. The committee have also examined and reported on samples of British and French laboratory glassware, produced since the beginning of the war, a number of the specimens being made from formulas similar to, and in some cases almost identical with, those recommended by the committee.

The committee have had before them many specimens of glasses used for various purposes of which analyses have been made by Mr. Blount, Mr. Hancock, and Mr. Heyner. It has been found, however, that mixtures prepared in accordance with the analytical results were not always satisfactory, but the analysis was helpful in suggesting synthetic experiments, and during recent investigations some intricate analyses made by Mr. Gilbert J. Alderton, under the supervision of Mr. Blount, have proved especially valuable. Apart from the analyses, the work has been almost entirely carried on at King's College by Professor Jackson and Mr. Merton, and by the former at his own house. The work has evolved a careful study of the chemistry of silicates, aluminates, borates, etc., in their relation to the manufacture of glasses. A detailed report of these experiments will be published in due course.

Up to the present time the research committee have reported eleven formulas for glasses for various purposes, based on the results of about 400 experimental melts on a scale large enough for drawing rods and blowing small vessels. In addition, a very great number of experiments have been made in order to study the influence of the various constituents employed. No formula has been issued without submitting the specimens made to rigorous tests to prove their suitability for the purpose for which they are intended. Moreover, by varying the experimental working conditions, it can be said with reasonable confidence that the mixtures will prove equally satisfactory under the actual working conditions of a glass furnace. The question of workable temperatures has been carefully considered, and so far as it is possible to judge, the melts on a small scale indicate that even better results will be obtained on the industrial scale. This view has been justified by the samples already received from manufacturers who have tried some of the formulas.

In deciding the formulas it has been found necessary to pay special attention to the proportion of basic and acidic substances in respect of the action of glass mixtures on clay crucibles during fusion, and it has been shown by careful investigation that the formulas pro-



posed give melts in which the influence of the ingredients of the crucibles is very slight, and in some cases practically inappreciable.

### The Iron and Steel Institute Meeting

#### THE FIRST DAY'S MEETING

It is not unknown in the chronicles of scientific institutions that a president should be unable to read his presidential address. But the *force majeure* has generally been a matter of the ruling of medical advisers rather than that of one's King's enemies. The stress of war kept Monsieur Adolphe Greiner from presiding at the May meeting of the Iron and Steel Institute this year. Indeed there was no presidential address, but after the formal business of the meeting first place was given to a paper by M. Greiner. Formal business under the chairmanship of Dr. Arthur Cooper included the annual report of the council indicating a satisfactory financial year, the announcement of the postponement *sine die* of the International Congress of Mining and Metallurgy, the presentation of the Bessemer Medal to M. de Fleurier, attaché to the French embassy, on behalf of M. Pierre Martin.

Mr. ADOLPHE GREINER's paper was then read—it was a brief but interesting note on “The Heating of an Open-Hearth Furnace by Means of Tar”—interesting not only technically but because of the circumstances leading to the solution of a fresh problem. In the author's words: “After the total stoppage of the works entailed by the foreign occupation, and once the preliminary period of disorganization had passed it appeared to us that we had a pressing duty before us—that of helping the working class population around us to the utmost extent of our power to earn its livelihood. For this reason I decided to undertake at once the manufacture of a portion of the orders we carried on our books so far as circumstances would allow.

The steel works were thus compelled to contemplate the necessity of relighting an open-hearth furnace. Our reserves of gas coal had been speedily exhausted; the only battery of coke ovens which was working was unable to furnish us with gas, of which it was itself in pressing need; the importation of British coal was impossible, and, as a matter of fact, we felt the need of freeing ourselves from the long established dependence of the works upon foreign countries as regards the supply of gas-coal. There remained as our sole resource the tar from the coke ovens.

In the present arrangement the tar is delivered to the sprayers (one only in each burner) with a regular feed and under a uniform pressure of half an atmosphere. It is sprayed by means of air compressed at about three atmospheres. The hot air of combustion is admitted above the injector through the existing port inclined at an angle of 45 deg. The average consumption of tar throughout the whole campaign has been 133 kg. (293 lb.) per ton of steel, including in this figure the amounts required for lighting up and for heating during stoppages. On the other hand, with an uninterrupted run this average falls to 115 kg. (253 lb.) per ton of steel. The average weight of the charges had to be diminished in order to avoid any deflection of the jet of flame issuing from the pulverizer toward the crown of the furnace. Nevertheless, several charges of 15 tons have been worked successfully without any other inconvenience than a proportionately longer working time. The proportion of pig-iron found necessary in the charge rose to 28 per cent.

I may add, after these 215 charges, the furnace is still in an excellent working condition. The roof appears even less damaged than after a similar campaign with coke-oven gas; only the chambers became encrusted.

The bricks of the checker work became covered with a carbonaceous substance, and it will be necessary to devise some means of remedying this inconvenience.

This paper was not discussed, Dr. Cooper remarking that it was really an addendum to Mr. Greiner's paper of last year. A hearty vote of thanks was accorded together with an acknowledgment of the value of his service and hopes for his continued activity.

The second paper, by Sir ROBERT HADFIELD and Dr. GEORGE K. BURGESS of the Bureau of Standards, Washington, on “Sound Steel Ingots and Rails” evoked a lengthy and spirited discussion. This was opened by Mr. B. Talbot, who criticised the authors for having based their standards on a comparison of special acid open-hearth ingots with ordinary acid Bessemer ingots instead of with basic open-hearth ingots. Mr. Talbot also asked for an explanation of the statement that casting big end up was superior to casting with the small end up, which was the invariable custom in rail and many other steel works. While Sir Robert's conclusion might be correct for small ingots, it was doubtful if it was safe to dogmatize for all sizes of ingots. He had had some photographs prepared of ingots of a weight in common use in rail works—namely, some 3½-ton ingots—in order to see what the results really were. As Sir Robert used a refractory top on his mould, he had done the same, so as to make a fair comparison. Personally, he was a believer in the brick-lined top when it was desired to reduce the piping in the ingot, or, at any rate, to bring the pipe nearer to the top, and it was to the use of that well-known device that he attributed Sir Robert's better results, rather than to his special blow-pipe arrangement, which he used in addition.

Mr. C. E. Stromeyer expressed the opinion, in regard to failures in steel plates, that these failures were largely due to the use of Bessemer steel scrap in the open-hearth furnaces, and that was one reason for which he welcomed the paper. In a general way, the question of piping and that of quality should, he thought, have been kept separate; the method might not improve the quality, although it might reduce the piping. Fractures in rails were not due to piping, but to defective material. Bad qualities of steel were very much worse at cold than at ordinary temperatures. He did not think the method would improve the quality, although it would reduce the piping.

Mr. W. H. Hewlett said that segregation was a very detrimental occurrence, and as Sir Robert Hadfield by his method reduced segregation he was rendering a very great service.

Mr. F. W. Harbord expressed the same opinion, adding that they welcomed any process which gave sounder ingots, and the reduction of blow holes was what all steel manufacturers had been aiming at. The proportion of seconds seemed to him very high, and he would have liked the figures to have been given for the American ingot also.

Mr. T. Twynam asked whether Sir Robert Hadfield had found an increase in the carbon content of the metal just below the cavity; in other words, did there occur carbon impregnation? He (the speaker) said he had found impregnation to occur, and he wanted to know whether the author had had the same experience. A segregation of carbon at that part was dangerous.

Sir Robert Hadfield, in replying to the discussion, said that he would be very pleased to reply fully to all remarks by correspondence. If Mr. Talbot made an ingot exactly on the lines indicated in the paper, he would obtain about 90 per cent of good work. The specimens of sound ingots he had exhibited in the rooms were all of converter steel. The War Office and Navy specifications were most difficult specifications to meet;

in order to show the success of his method of manufacture, he added that ingots manufactured by his firm to the number of 120 had been cut through, and not one had been found defective. The ingots in question were representative of makes which extended over a period of from seven to eight months. If Mr. Talbot obtained similarly good results, he (Sir Robert) would be the first to congratulate him. When casting the larger end upwards, he (the author) added that there was a large ferro-static pressure, and a better result was obtained. In regard to Mr. Stromeyer's remarks, Sir Robert stated that his method of manufacturing the ingots did certainly lead to the manufacture of better rails, as was evidenced by the etchings. In the matter of carbon impregnation, when 9 to 10 per cent discard was cut off, all trace of carbon impregnation was removed with the discard; if it were not so, the British Government would have rejected material for that reason, and so far there had been no rejection in a total quantity of about 70,000 tons of ingots made in the manner described.

Comments on the second day's proceedings are held over to my next issue.

### Market Prices

MAY, 1915

*Tin* showed a downward movement at the beginning of the month, but stronger in the last fortnight. It opened £159.10, rose sharply to £162.10 (3rd), dropped to £160.10 (4th), then rose to £165.10 (10th), fell slowly to £162.10 (14th), and after a slight rise declined to £160.10 (19th). It then improved to £164 (25th), but fell away again after to £162 (26th) and closes £163.5.

*Copper* opened £76 and rose smartly to £79.10 (7th). It then dropped to £77.12.6 (11th), but recovered to £79.15 on the 12th. Declining slowly it touched £75.5 on the 19th, but recovered to £76.17.6 on the 20th. On the 21st it was again £75.7.6. It then rose decidedly, being £78.15 by the 28th, and closes £79.2.6.

*Haematite* has been 95/- throughout the month.

*Scotch Pig* opened 70/- and after rising to 70/10½ on the 6th was inclined to weaken, being down to 69/3 on the 10th. It then appreciated to 71/4½ on the 12th, but went lower to 69/10½ on the 14th, recovering to 71/- on the 17th. It kept at 71/1½ after the Whitsun holidays till 25th, rising to 71/9 on the 26th.

*Cleveland* opened 64/- and rose to 66/10½ on the 6th, then dropping to 64/7½ on the 11th and 55/4½ on the 12th. On the 14th it was 63/10½; it then recovered to 65/7½ (25th), but subsequently went lower, closing 65/7.

*English Lead* opened £21, then dropped to £20 (5th), sharply recovering to £21.5 (7th), and keeping between £20.15 and £21, and closes £21.10.0.

	£	s.	d.
Aluminium, ingots, ton lots.....	90	0	0
Antimony, Bk. sulphide powder, ton.....	70	0	0
Borax, British refined crystal, cwt.....	22	0	0
Copper sulphate, ton.....	29	0	0
Caustic soda, 70 per cent ton.....	10	2	6
Ebonite rod, lb.....	3	0	0
Hydrochloric acid, cwt.....	4	6	6
India rubber, Para fine, lb.....	2	7	½
Mica in orig. cases, medium, lb.....	3 to 5	0	0
Quicksilver (Spanish), bottle.....	12	2	6
Sal-Ammoniac, cwt.....	49	0	0
Sulphur, recovered, ton.....	8	0	0
Shellac, cwt.....	3	5	0
Platinum, oz. nominal.....	9	5	0

An antimony refinery is reported under construction at Harbor Industrial City, Cal. The capacity is said to be 1500 tons per month, and the operating company is reported to be producing ore from desert claims in southern California.

## Synopsis of Recent Chemical and Metallurgical Literature

### Gold and Silver

**Concentration of Gold in Bottoms in the Copper Converter.**—A method of recovering the gold in converter copper not rich enough to warrant electrolytic refining, is described by Mr. H. F. COLLINS in *Bulletin* No. 128, Inst. Min. & Met. The process has been standard practice at Cueva de la Mora since November, 1914. The operation depends on the incomplete oxidation of white metal to "pimple" metal and "bottoms," and separation of the latter before completing the oxidation. The author has adapted it to 3-ton acid-lined converters by providing a cast-iron tapping block opposite the tuyeres, having a tap-hole 1½ in. in diameter.

"When the lining is being rammed this hole has an ordinary 7/8-in. steel bar pushed through up to within an inch of the mould, so that the lining may be rammed round it as tightly as possible, and when the moulds are removed the bar is at the same time withdrawn in order to facilitate 'drying out.'

"When the converter is placed upon the stand for use the tap-hole is closed by a plug of clay, and a short 7/8-in. bar is then driven in so as just to protrude on the inside of the lining while the head stands out some 16 to 20 in. from the front of the converter shell. After blowing to precipitate as metal the required quantity of copper, the converter is turned down till the bar stands at about 75 deg. from the horizontal.

"After knocking it in an inch or so in order to penetrate any skin of copper that may have formed on the inside, the usual ring and wedge are affixed, and the bar is driven out as quickly as possible by rapid blows; as its point leaves the converter shell the mould car held in readiness at the back is rapidly pushed forward, while the converter is at the same time turned until the tap-hole is vertical.

"After one, two or three moulds have been filled, according to the size of the charge, and the issuing stream is evidently white metal and not copper, the converter is turned up as rapidly as possible, the tap-hole being plugged with clay while in motion until the next operation, and blowing is restarted to finish the charge as usual."

The success of the operation depends on not losing too much time in skimming and not adding too much scrap after skimming, so that the reduced copper is at a temperature above the melting point of the pimple metal.

"As regards the concentration of gold in the bottoms, in practice it is easy to recover 70 per cent of the gold originally existing in the charge in the form of bottoms, amounting to 9 per cent of the total weight of converter copper produced, and 25 times as rich. The richness of the bottoms in gold depends upon the relative proportions of bottoms and residue bars from each charge."

The workmen apparently have no difficulty in becoming expert in operating the converter in the proper manner, and in securing bottoms of uniform weight and value.

"In order to obtain good results, it is necessary to hit the point of 'white metal' with considerable nicety before the final skimming prior to commencing the blowing for bottoms, since if the white metal is low and contains more than 4 per cent iron, as occasionally happens when the skimmer is either careless or timid, the time required for oxidation of the excess iron will vitiate the calculation of that required for blowing to 'bottoms'; and insufficient copper will be reduced. Pro-



vided, however, the point at which the white metal is skimmed be kept fairly uniform, it is only necessary to proportion the time for 'bottoms blowing' roughly to the size of the charge."

**Assay of Gold-Bearing Cyanide Solution.**—A method for this purpose that has been in long use at the St. John del Rey property, Morro Velho, Brazil, is published in *Bulletin* No. 128, *Inst. Min. & Met.*, by Messrs. DONALD M. LEVY and HAROLD JONES. The method is based on the precipitation of the gold by means of zinc shavings, or a zinc-lead couple, from the boiling solution, in the presence of suitable quantities of silver and lead salts. Sufficient silver is introduced to form a parting alloy in the button. The following stock solutions are used:

**Silver Solution.**—1 grain silver per 10 cc. Dissolve 36 grains silver nitrate in water, add sodium cyanide in small quantities till the precipitate first formed is just dissolved. Dilute the solution to 2½ liters.

**Sodium Cyanide Solution.**—10 per cent. Dissolve 250 to 260 grams sodium cyanide in 2½ liters of water.

**Sodium Plumbite Solution.**—Dissolve 65 grams lead acetate in water, add sodium hydroxide solution till the precipitate first formed just redissolves, then dilute to 2½ liters.

The quantity of solution taken for each test is one two-thousandth part of the I. M. M. ton (7000 grains, or 453.6 cc.), so that using the ordinary bullion assay weights for weighing the final gold the result is read off directly as grains fine gold per ton. "This volume of solution is poured into a flask of 1¼ liters capacity and the silver solution is added; for the rich solutions (before passing zinc-boxes), 15 cc. of the silver solution are used, for the poor solutions (after passing zinc-boxes) and for wash-waters only 5 cc.

"Next 10 cc. of the sodium cyanide solution are added, then 5 cc. of the plumbite solution, and the mixture shaken.

"Twenty grams of zinc-shavings are now placed into the solution and the contents of the flask gently boiled for half an hour and then filtered at once, through a 9-in. filter-paper, the clear filtrate being rejected. To the flask containing the residual zinc-shavings a little water is added (say about 20 cc., only just so much being required as will prevent the cracking of the flask by the drying and heat produced on the subsequent addition of acid), then 70 cc. of commercial hydrochloric acid. After the complete solution of the zinc the contents of the flask are poured onto the filter, flask and filter being subsequently well washed with water.

"The wet filter is now transferred to an assay crucible placed in the furnace, dried slowly and then simply carbonized at a moderate heat, and the pot withdrawn from the fire. The following fluxing charge is now added:

Red lead .....	12.5 gfm.
Borax .....	22.5 gfm.
Sodium carbonate .....	12.5 gfm.
Sodium chloride .....	2.0 gfm.
Flour .....	2.0 gfm.
Powdered glass .....	2.0 gfm.
Potassium nitrate .....	2.0 gfm.

"The crucible is returned to the furnace and the charge run down in the usual manner, from twenty to thirty minutes being required to complete the fusion, after which the contents of the crucible are poured, the metallic button detached and cupelled in a small magnesite cupel, the resulting beads being rolled out and parted directly in the usual manner."

#### Zinc and Lead

**Flotation at the Timber Butte Mill, Montana.**—In a paper to be presented at the San Francisco meeting of the American Institute of Mining Engineers next Sep-

tember, Mr. THEODORE SIMONS gives many details of the design, construction and operation of the Timber Butte concentrator now treating Elm Orlu zinc ore. Since flotation plays an important part in the scheme of treatment at this mill, the information given on that point is timely. The ore contains zinc, lead, copper, gold and silver. The gangue minerals are quartz, barite, fluorite, rhodonite and rhodocrosite. The ultimate aim of the treatment process is to produce three classes of concentrates suitable for copper, lead and zinc smelters. Table I gives the metallic contents of crude ore and mill products.

TABLE I.—AVERAGE ANALYSIS OF CRUDE ORE, CONCENTRATES AND TAILINGS

Name of Product	Cu Per Cent	Ag oz. per Ton	Au oz. per Ton	Fe Per Cent	Zn Per Cent	Pb Per Cent	Insol. Per Cent
Original ore .....	0.73	6.23	0.013	3.29	18.52	0.75	62.23
Copper-iron conc. ....	2.25	21.01	0.04	19.78	22.78	13.01	2.30
Lead-iron conc. ....	1.13	18.91	0.04	9.99	9.15	50.60	5.05
Coarse-zinc conc. ....	1.96	14.74	0.035	9.15	47.77	1.88	3.47
Fine-zinc conc. ....	2.22	16.84	0.036	4.45	52.44	1.72	5.05
Tailings .....	0.07	0.60	0.0017	0.44	1.20	0.05	95.42

The design and flow-sheet (Fig. 1) of the mill are the result of extensive tests. There are but two essential operations in the process: table concentration and flotation. Wilfley and James roughing tables make a lead-iron product rich enough for retreatment, and a finished zinc concentrate, the latter representing 25 per cent to 30 per cent of the total original zinc in the ore.

The mill proper consists of three separate buildings, connected by runways for conveyors and concentrate launders. The lower building, 155 by 70 ft. in size, contains the concentrate plant and bins, the coarse-ore bins and coarse breakers, the boiler plant and coal bins. The next higher building, 260 by 80 ft., contains the roll-crushing, table-concentration, and flotation plants. The highest building, 20 by 30 ft., contains the supply bin and feeders.

Rough concentration begins on No. 8 Wilfley tables, the feed ranging in size from 2.5 mm. to the finest product of crushing. Each table handles 100 tons of ore per day. In addition to the finished coarse zinc concentrate of about 50 per cent grade, several intermediate products are cut out for regrinding and further treatment by classification, jigging and concentration on Wilfley and James tables. The tailings from the James sand tables are reground for final separation of sulphides by flotation.

To unlock the finest included grains of mineral from Elm Orlu ore it is necessary to grind to about 60 mesh, and this is the maximum size of the flotation feed. The pulp is kept at a uniform density of three parts of water to one of ore, and is heated to a temperature of 130° F. by the introduction of live steam. Temperatures below 125° F. reduce the efficiency of the operation. Sulphuric acid also has been found essential, and is added at the rate of 7 to 8 lb. per ton of original ore. Oil is added at the rate of 0.5 lb. per ton. An outline of a cell of the Minerals Separation machine is shown in Fig. 2. Oil is introduced in the mixing compartment (A) of the first cell where the pulp is violently churned by the action of the agitator (B), which at this plant makes 265 rev. per minute and causes the propellers (C) to run at a peripheral speed of about 1500 ft. per minute. The aerated mixture passes through the opening (D) into the flotation compartment (E), where the froth containing the sulphides of lead, copper, zinc and iron, as well as some of the richer middlings, immediately rises to the surface, while the clean gangue and the leaner middlings drop to the bottom.

The flotation compartment has the shape of a spitz-

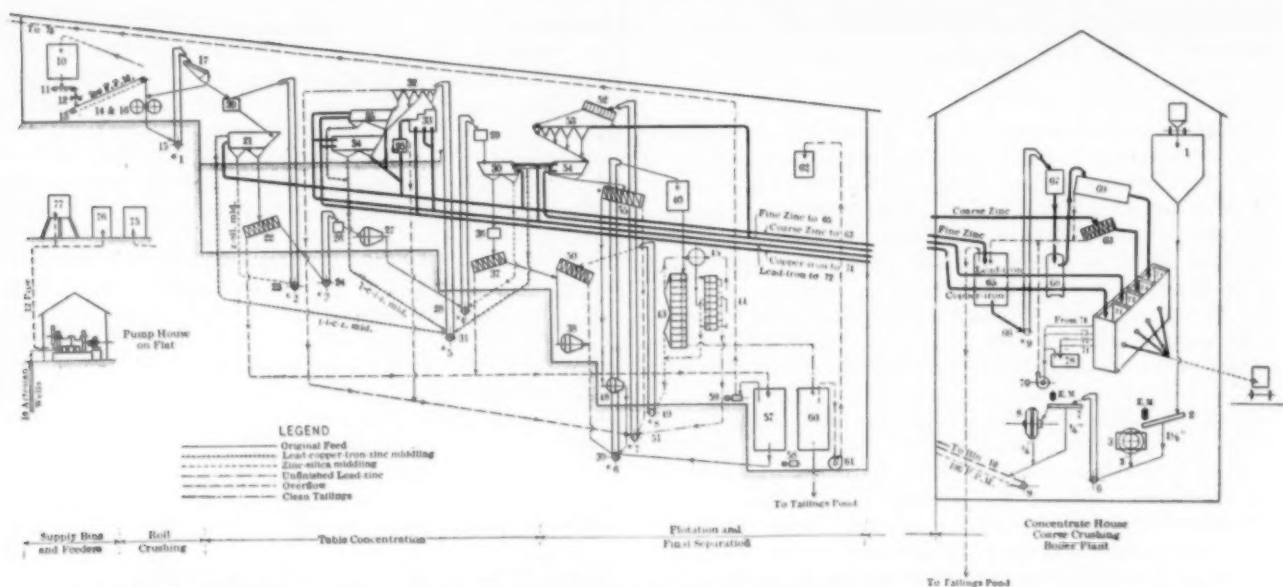


FIG. 1—PRINCIPAL MACHINES AND ACCESSORIES IN THE CONCENTRATOR OF THE TIMBER BUTTE MILLING CO., SHOWN ON FLOW SHEET

Flow Sheet Number	Number of Pieces	Description of Machine			
1	2	Crude-ore bins, 750 tons combined capacity.	33	1	Double, three-compartment Harz jig.
2	1	Shaking-screen feeder, 1½-in. square openings.	34	2	No. 6 Wilfley tables, 240 strokes per minute.
3	1	15 by 30 in. Farrel jaw crusher, crushing to 3 in.	35	1	No. 3 James sand table, 262 strokes per minute.
6	1	Steel elevator, 32-ft. centers—95 ft. per minute.	36	1	Distributing box.
7	1	3 by 8-ft. Symons pulsating screen, 375 strokes per minute, ¾-in. round openings.	37	2	45-in. Akins classifiers, 5 rev. per minute.
8	1	Symons 36-in., style C disk crusher, 133 and 300 rev. per minute, crushing to ¾ in.	38	2	8-ft. by 30-in. Hardinge mills, 28 rev. per minute.
9	1	24-in. inclined belt conveyor, 196 ft. per minute.	39	1	No. 6 belt elevator, 58-ft. centers, 490 ft. per minute.
10	1	Secondary ore bin, 1200 tons capacity.	40	1	16 by 10 ft. sludge tank, 10 rev. per minute.
11	4	24-in. steel apron feeders, 5 ft. per minute.	43	1	Standard Minerals Separation 11-cell flotation machine, capacity 600 tons.
12	1	20-in. horizontal belt conveyor, 250 ft. per minute.	44	1	Standard Minerals Separation 8-cell flotation machine, capacity 200 tons.
13	1	20-in. inclined belt conveyor, 250 ft. per minute.	45	1	Air lift.
14	1	54 by 18 in. Garfield rolls, 83 rev. per minute.	48	1	4½-ft. Hardinge mill, 32 rev. per minute.
15	1	No. 1 belt elevator, 84-ft. centers, 415 ft. per minute.	49	1	No. 8 belt elevator, 58-ft. centers, 490 ft. per minute.
16	1	54 by 18 in. Garfield rolls, 83 rev. per minute.	50	3	45-in. Akins classifiers, 5 rev. per minute.
17	4	C.I.W. Impact screens, 50 strokes per minute, 2½-mm square openings.	51	1	No. 7 belt elevator, 81-ft. centers, 490 ft. per minute.
20	1	Eight-compartment mechanical distributor, 21 rev. per minute.	52	1	Esperanza classifier, 25 ft. per minute.
21	8	No. 8 Wilfley roughing tables, 243 strokes per minute.	53	1	Five-spigot Richards hindered-settling classifier, 100 tons capacity.
22	2	45-in. Akins classifiers, 5 rev. per minute.	54	7	No. 3 James sand tables, 265 strokes per minute.
23	1	No. 2 belt elevator, 72-ft. centers, 400 ft. per minute.	55	1	30-in. Akins classifier, 5 rev. per minute.
24	1	No. 3 belt elevator, 50-ft. centers, 400 ft. per minute.	57	1	36-ft. Dorr thickener, 1/10 rev. per minute.
25	1	Dewatering box.	58	1	Cameron steam pump.
26	1	Three-compartment distributor.	59	1	Cameron steam pump.
27	3	8-ft. by 30-in. Hardinge mills, 28 rev. per minute.	60	1	36-ft. Dorr thickener, 1/10 rev. per minute.
28	1	No. 4 belt elevator, 58-ft. centers, 400 ft. per minute.	61	1	Two-stage centrifugal pump 1½ in.
29	1	Eight-compartment mechanical distributor, 21 rev. per minute.	62	1	10 by 10 ft. hot-water tank.
30	8	No. 3 James sand tables, 262 strokes per minute.	63	1	45-in. Akins classifier, 5 rev. per minute.
31	1	No. 5 belt elevator, 80-ft. centers, 400 ft. per minute.	65	2	28-ft. Dorr thickeners, ¼ rev. per minute.
32	1	Five-spigot Richards hindered-settling classifier, 40 tons capacity.	66	1	No. 9 belt elevator, 52-ft. centers, 440 ft. per minute.
			67	1	14 by 10 ft. agitating tank.
			68	1	8 by 15½ in. Montefu tank.
			69	1	Kelly filter press, type 850.
			70	1	Two-stage centrifugal pump.
			71	2	Copper-concentrates bins.
			72	2	Lead-concentrates bins.
			73	2	Coarse-zinc concentrates bins.
			74	2	Fine-zinc concentrates bins.
			75	1	30,000-gal. dirty-water tank.
			76	1	30,000-gal. fresh-water supply tank.
			77	1	50,000-gal. sprinkler tank for fire protection.
			78	2	Settling boxes in concentrate house.

kasten, the apex of which is provided with a valve (F), adjustable by a hand wheel (G). Through this valve the material that has settled to the bottom of the first cell is drawn into the adjoining cell by the pumping action of its propeller. The process is here repeated and sulphides which did not float in the first cell are given a chance to do so in the second one, and so on.

The agitating compartments of the flotation cells are lined with cast iron, and the propellers are made of brass. All agitators of a standard machine are driven from one main shaft by gears which are protected from dust by steel housings. Gears are placed so that propellers in adjoining cells revolve in opposite directions, thus equalizing the strains on the machine and the power transmission.

The following statement gives in detail the flow of ore through the flotation section:

"From the sludge tank (40), which acts as an equalizer between the gravity-concentration and flotation section, the pulp flows to a standard 600-ton Minerals Separation unit (43) known as the 'rougher machine.' It consists of eleven cells, each divided into a mixing or agitating and a flotation compartment. The intensely agitated pulp discharges from the mixing into the flotation compartment, where the pulp is comparatively still and where a portion of the sulphide minerals rises to the surface to be skimmed off by revolving paddles and discharged into a launder in front of the cells. The remainder of the sulphides and the gangue that has settled to the bottom of each flotation



compartment are drawn into the adjoining cell by the pumping action of its agitator. Here the process is repeated and sulphides not floated in the first cell are given a chance in the second cell, and so on.

"The overflow from the last five cells of the 'rougher machine' (43) is a middling that goes via No. 8 elevator (49) to Akins classifiers (50). The classifier overflow returns to the 'rougher machine' of the flotation section. Sands are reground in two 8-ft. by 30-in. Hardinge mills (38) to an approximate 60-mesh maximum size and return via No. 6 elevator (39) to flotation section.

"Finished tailings from the eleventh cell of the 'rougher machine' (43) flow to a 36-ft. Dorr thickener (60) to be partly dewatered and thence to the tailings pond. The overflow from this tank is hot water, free from solids. It is pumped by a two-stage centrifugal

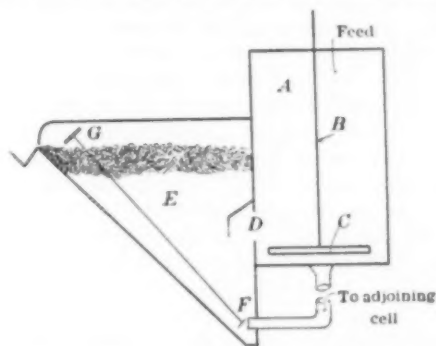


FIG. 2—OUTLINE OF M. S. FLOTATION CELL

pump (61) to a 10 by 10 ft. tank (62), which supplies the flotation machines with hot water.

"The mixed sulphide concentrate which overflows from the first six cells of the 'rougher machine' (43) goes via air lift (45) to a 200-ton Minerals Separation unit (44), consisting of eight cells, known as the 'finisher.' Here the 'rougher' concentrates are refloatated for the purpose of removing more of the gangue minerals. Cells Nos. 1—2—3—5—6—7 of this machine (44) make a float sulphide which goes via No. 7 elevator (51) to classifiers and James tables for final separation of lead and iron from the zinc.

"Overflow from cells 4 and 8 of 'finisher' (44) returns via air left (45) to the same unit. The bottom discharge from cells 4 and 8 is a middling which joins the middlings from the 'rougher machine' (43) to be reground in Hardinge mills (38) and returned to the flotation section.

"The float concentrates from unit (44) are lifted by No. 7 elevator (51) to an Esperanza classifier (52), the overflow from which is a finished fine zinc concentrate that goes to two 28-ft. Dorr thickeners (65) in the concentrate building. Sands go to a five-spigot Richards hindered-settling classifier (53), whose overflow is a finished fine zinc concentrate, which joins the overflow of the Esperanza classifier.

"The discharge from the five spigots of the Richards classifier is distributed on seven No. 3 James sand tables (54), where the lead and zinc are separated and the insolubles in the zinc concentrate reduced to about 3.5 per cent. Each table makes the following products:

"1. A finished lead concentrate, which goes to bin (72).

"2. A lead-copper-iron-zinc middling, which is returned via No. 5 elevator (31) to the primary jig and table retreatment circuit.

"3. A fine zinc concentrate, which goes to Dorr thickeners (65) in the concentrate building to be partly dewatered.

"4. A tailing, which is reground in a 4½-ft. Hardinge

mill (48) after passing through a 30-in. Akins classifier (55) whose overflow returns via No. 7 elevator (51) to the final table-separation circuit.

"The product of the Hardinge mill (48), which is of about 60-mesh maximum size, goes to flotation section via No. 6 elevator (39).

"The Dorr thickener (57) receives practically all the fines and slimes coming from the mine and those made in the crushing operations. The overflow is dirty water, which is pumped by a double Cameron steam pump (59) to the 'dirty-water tank' (75) at the top of the mill, whence it returns for circulation throughout the mill. A duplicate auxiliary Cameron pump (58) is put into service whenever pump (59) is stopped for repairs. From the bottom of tank (57) the thickened pulp is lifted by hydrostatic pressure to the boot of No. 6 elevator (39) to go to flotation section."

Taking the mill as a whole, the ratio of concentration for zinc is 2.89, and for lead and iron 125, approximately 20 per cent of which is lead concentrate. Treatment costs have averaged between \$2 and \$2.25 per ton of crude ore, including labor, power, water, supplies, repairs and general expenses, but not interest on investment or depreciation. Extraction is about 96 per cent for zinc and 92.6 per cent for silver.

## Recent Chemical and Metallurgical Patents

### Copper and Zinc

**Leaching Copper with Ammoniacal Solutions.**—The proposed method of leaching metallic copper from the tailings at the Calumet & Hecla, in Michigan, is disclosed in a patent granted to Mr. C. H. BENEDICT, metallurgist for the company. A brief statement of the

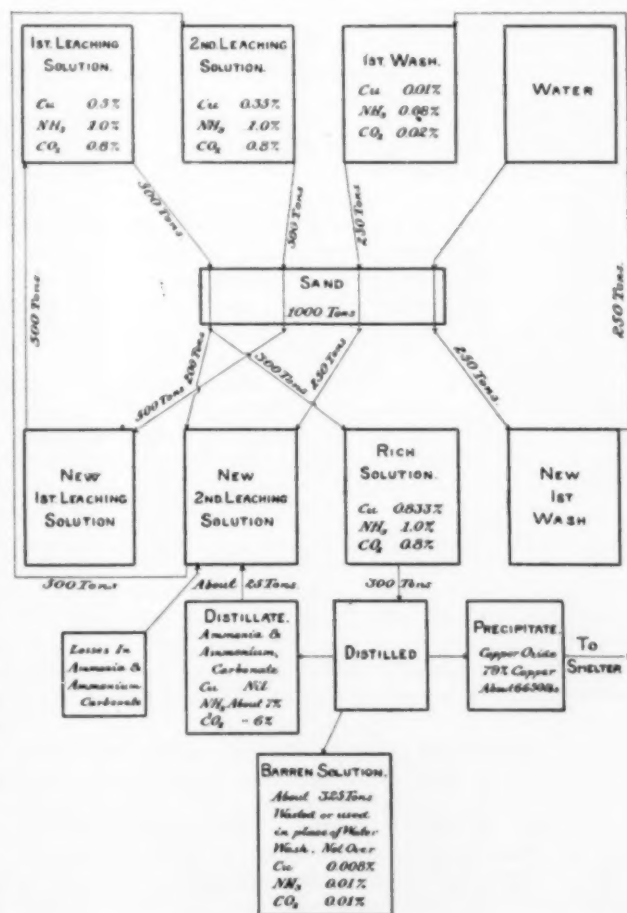


FIG. 1—AMMONIA LEACHING PROCESS FOR METALLIC COPPER ORES

process appeared in METALLURGICAL AND CHEMICAL ENGINEERING for April, 1915, page 233. The flow-sheet of the process is represented in the accompanying Fig. 3. In view of the interest in the process, we give an extended abstract of the patent specifications, which are unusually instructive and complete.

"It has long been recognized that—(1) copper oxide will dissolve in ammoniacal solutions, yielding copper-ammonium compounds; (2) solutions of cupric-ammonium salts are capable of dissolving native or metallic copper, yielding cuprous-ammonium salts; (3) these cuprous-ammonium salts may be oxidized, by air or other suitable oxidizing agents, to cupric-ammonium salts; and (4) copper-ammonium solutions subjected to distillation are decomposed with separation of copper oxide, ammonia being volatilized." The difficulties encountered in applying these ammoniacal solutions to copper extraction in a commercial way have been the heavy loss in ammonia and the high cost of apparatus adequate to prevent such losses. According to Mr. Benedict's investigations, he is of the opinion that the loss of ammonia is not due exclusively to volatilization, but to adsorption of ammonia by the fine sands and especially by slimes. He has discovered also that this adsorption is generally proportionate to the concentration of ammoniacal solution, being less in dilute than in strong solutions. Thus, in solutions containing 2 per cent or less  $\text{NH}_3$  in the free state, adsorption is so small as to be negligible from the aspect of commercial success.

"It is a primary object of the present invention so to operate a cyclical leaching-process as to render it practicable to use these highly dilute ammoniacal solutions of copper for solvent purposes, securing thereby the advantage of small or negligible losses of ammonia and of copper, without unduly increasing the cost and size of the installation. To this end, the cycle of operations is so arranged that an amount of copper equal to that extracted from a given batch of ore will be found concentrated in a relatively small proportion of the total volume of solution brought into contact with this ore. A suitable volume of this stronger solution is subjected to distillation to precipitate its copper-content in the form of oxid, and to recover the free ammonia and any volatile ammonium salts, which are restored to the cycle at the appropriate point, the volume so distilled preferably containing an amount of copper practically equal to the total quantity of copper extracted from the ore in the same cycle."

"The four typical solutions, as applied to a sand assaying approximately 0.5 per cent of copper, in the order of their application to the sand, are designated and characterized as follows, percentages being by weight:

(1) "First leaching solution": 0.5 per cent Cu: 1.0 per cent  $\text{NH}_3$ : 0.8 per cent  $\text{CO}_2$ .

(2) "Second leaching solution": 0.35 per cent Cu: 1.0 per cent  $\text{NH}_3$ : 0.8 per cent  $\text{CO}_2$ .

(3) First wash": 0.01 per cent Cu: 0.08 per cent  $\text{NH}_3$ : 0.02 per cent  $\text{CO}_2$ .

(4) "Second wash": Water, or a distillation reject containing only traces of copper and ammoniacal compounds."

"Sand finer than forty mesh, previously freed from slime by means of a Dorr classifier or otherwise, is run into a tank which for illustrative purposes may be 54 ft. in diameter by 12 ft. high. This tank should be covered, fitted with valve-controlled vents, provided with a false bottom of filter-cloth supported on a wooden frame and fitted with an overflow and with appropriate means for receiving and delivering the sand and the various solutions. The sand is run in with water in

such manner as to be uniformly distributed. After one thousand tons of sand have been delivered to the tank, filling it with sand to a height of about 10 ft., the water meanwhile overflowing, the excess water is removed by decantation and the sand drained to the surface. The first bleaching solution is then led into the tank from above, the bottom valve opened, and the water displaced at as rapid a rate as filtration will permit. As soon as ammonia begins to appear at the outflow, indicating substantial displacement of the water, the lower valve is partially closed and the percolation rate adjusted as may be found necessary to secure a satisfactory solution of the copper-content of the ore. The first portions of the solution are found to be poor in copper and low in ammonia-content, owing to diffusion and imperfect displacement, and are run into the sump for the second leaching solution. Soon the first leaching solution, properly enriched in copper and now termed 'rich' solution, appears and is permitted to flow to the 'rich' solution tanks for subsequent distillation. This 'rich' solution is the richest portion of the effluent coming from the sand, and is ready for distillation. The volume of rich solution distilled for any one batch of sand is dependent upon the copper-content of the sand, and in practice will be, on the average, such volume that the copper-content of the rich solution distilled is practically equal to the copper extracted from the sand. The rich solution on distillation breaks up into copper oxid for the smelter, ammonia and ammonium carbonate for the second leaching solution, and a reject containing traces only of copper, ammonia and ammonium carbonate; this reject may be used instead of water for the second wash if desired."

"As soon as the first leaching solution, amounting in all to some five hundred tons, has been run upon the sand and has reached the sand line, the second leaching solution is run in, in approximately equal volume; and when this in turn has all reached the sand line, the first wash is added, followed in the same manner by the second wash, the effort in all cases being to avoid mixing solutions, and to displace each by that next succeeding it in the cycle. The several effluent solutions are so manipulated as practically to maintain the proper composition balance, as between the chemical contents of the various solutions, a typical method by which this may be done being illustrated graphically in the diagram before referred to. There is thus established an equilibrium in the process, there being also a regular progression of solutions in the following general manner: The second wash of charge N takes up a little copper and becomes the first wash of charge N + 1; this in turn takes up a little more copper and receives the distillate and some dissolved copper from previous cycles and becomes the second leaching solution of charge N + 2; the free ammonia of this second leaching solution is partially used in dissolving copper, when it becomes the first leaching solution of charge N + 3, its copper content having been fully oxidized to the cupric condition; this first leaching solution having become saturated with copper by its passage through the sands, and having thereby lost its solvent power, is in part distilled, as before described, depositing its copper values as a 79 per cent oxid, yielding its ammonia and ammonium carbonate as a pure product to join cycle N + 4 as a second leaching solution, and furnishing from its almost barren reject a second wash for a following cycle. In a plant containing more than one leaching tank, these several operations are of course all going on at the same time, the total volume of solution in circulation being practically a constant: thus "rich" solution is continuously withdrawn from the leaching circuit, and is replaced by an equal volume of



oxidation through the surface contact of the dilute solutions with the atmosphere, particularly after the process has reached the desired equilibrium, so that relatively large amounts of copper are being carried in solution.

"It is accordingly quite unnecessary, as a rule, in the regular operation of the process, to use any system of mechanical aeration of the several solutions. These are stored in covered tanks, with controlled vents, whereby air may be admitted as required. Means for injecting air under pressure may also be fitted both to the storage and leaching tanks. It has further been shown, in practice, that whereas there is some appreciable adsorption of ammonia by the sands, even from solutions so dilute as those contemplated under the present invention, the adsorption of copper is practically nil; and the losses of copper are materially reduced by the employment, as described, of at least two leaching solutions, applied successively, the second leaching solution being poorer in copper than the first, and both solutions being highly dilute.

"Obviously, the loss due to ammonia adsorption may be somewhat lessened by repeated washings, and it is possible and may be advisable to have a 'third wash' following the 'second wash,' the expediency of this being a commercial circuit of pipes, pumps, storage room, and the like. So, too, the balance between the amount of 'rich' solution distilled and 'second wash' used is in part a commercial one, depending upon the cost of steam and the distillation loss, as against the recovery of additional copper and ammonia by more complete washing."—(1,131,986, Mar. 16, 1915.)

**Copper Hydrometallurgy.**—Improvements in the treatment of such copper ores as chalcopyrite and chalcocite, by roasting, leaching and electrolysis are contained in a process patented by Mr. E. A. CAPPELEN SMITH of New York City. In the roasting process the ore is treated in a furnace of the Wedge or Herreshoff seven-hearth type, at a temperature of between 600 deg. C. and 750 deg. C. in the first five hearths and between 450 deg. C. and 500 deg. C. in the last two hearths. In

tion returned from the electrolytic vats. The solution thus employed will contain usually about 10 to 12 per cent of free sulphuric acid, and say from 1.5 per cent to 2.5 per cent of copper, according to the extent to which the electrolysis has been carried. Practically all the copper still remaining in the partially leached ore is taken into solution by this leach liquor, and also a very small amount of iron in the ferric state; the resulting solution is then drained into another agitating tank, where, in order to remove the ferric iron, a fresh batch of ore from the roasting furnace is added in sufficient quantity to neutralize practically all of the acid remaining in the solution. By this operation, the ferric iron taken up from the partially leached ore by the acid electrolyzed solution, is precipitated as a basic sulphate of iron, while about 85 per cent of the copper contained in the fresh batch of ore used in the neutralizing leaching is dissolved. The solution and the ore are then withdrawn to a settling tank, where the partially leached ore quickly separates out from the solution, which latter retains suspended therein, practically all of the basic iron salts. The solution is then immediately tapped off or siphoned off from the top of the ore before it has time to deposit any material part of its salts in the ore. It is then filter pressed, which removes the suspended iron salts and gives a clear electrolyte, almost devoid of iron salts, which electrolyte then passes to the electrolytic tanks.

In the electrolytic tanks, the copper is electrolyzed out of the solution between a practically insoluble or non-corrodible anode and a copper cathode. For the insoluble or non-corrodible anode, the usual lead anode, preferably having a small proportion of antimony may be employed. It has not always been possible to conduct the roasting operation in such manner that all of the iron present in the ore is converted into ferric iron; a small amount, say, less than 1 per cent, will usually remain as ferrous iron, and, in the leaching which follows, this ferrous iron being much more readily soluble in sulphuric acid than the ferric iron will enter the solution. After the ferrous iron is in the solution it will run through the operation up to the point of electrolysis. At a certain stage of the electrolysis, however, practically all of the iron present in the electrolyte is converted into ferric iron. If now it should be found desirable to remove the iron from the solution, the electrolysis can be stopped at this point and the solution can be used over again in leaching, whereupon, in the neutralizing leaching, all of the iron in solution which is now in the ferric state will be precipitated, even including the iron which originated from the ferrous iron present in the roasted ore. If the electrolysis is continued until the solution is very low in copper, the small amount of iron remaining dissolved in the solution will be reconverted into ferrous sulphate, which is not removable, as a basic sulphate in the neutralizing leaching." (1,134,767, April 6, 1915.)

**A briquet for use in zinc furnaces** is patented by Mr. GEORGE S. BROOKS of Depue, Ill., and assigned to the New Jersey Zinc Company. It is composed of four parts by weight of zinc ore crushed to the usual degree of fineness; one part of more finely powdered ore, or in lieu thereof, one part of commercial zinc oxide; one and one-half parts of powdered coal; and a sufficient quantity of common salt dissolved in water, to form a thick plastic mixture of the several ingredients. The amount of salt usually used is about 1½ per cent in weight of the ore in the mixture. The mixture is pugged and formed into briquets about 7½ in. in diameter and 7 in. long.

The briquets, in whatever way formed, are then subjected to about 90-lb. pressure per square inch. The briquets are kiln-dried for twenty-four hours at a tem-

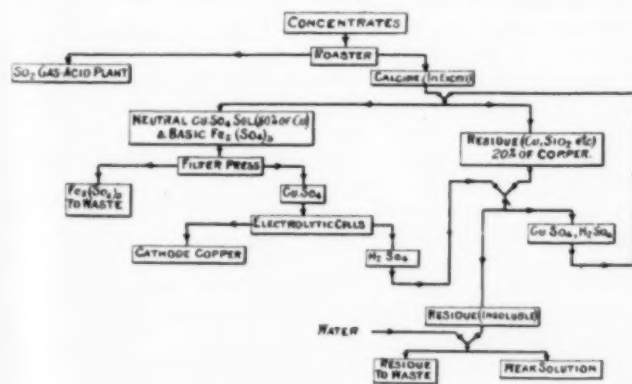


FIG. 1—COPPER LEACHING PROCESS

the hotter hearths sulphur is eliminated and FeO formed; in the last two cooler hearths the FeO is converted into Fe<sub>2</sub>O<sub>3</sub>. The copper compounds are completely oxidized, and the iron content is in a form practically insoluble in sulphuric acid.

The roaster gases are converted into sulphuric acid for leaching.

A diagrammatic flow sheet of the process is shown in Fig. 1. The process is cyclic, and is thus described:

"Assuming that the cycle of operations is fully under way, a quantity of partially leached ore from which about 85 per cent of the copper has been removed, in the step hereinafter referred to as the neutralizing leaching, is treated by agitation with the electrolyzed solu-

perature of about 200 deg. F. During the drying the salt forms a crust or shell on the surface of the briquet, which protects it in handling and forms a filter about the ore through which the distilled zinc must pass. This results in a high production of spelter and a reduction in production of blue powder. The briquets are charged into the retorts by means of a semi-cylindrical chute long enough to contain enough briquets to fill the retort. With 50-in. retorts, six 7-in. briquets form a charge. The practice increases the capacity of retorts about 15 per cent to 20 per cent, and when the reduced quantity of blue powder requiring further smelting is taken into consideration, the capacity of a furnace treating briquets is increased 33 1/3 per cent. (1,137,835, May 4, 1915.)

### Iron and Steel

**Sintering Ores.**—In a patent granted to Mr. ALBERT F. PLOCK of Pittsburgh, Pa., and assigned by him to the Pittsburgh Metallurgical Company, disclosure is made of apparatus for sintering ores. Fig. 2 shows the arrangement of apparatus. Cars 10 provided with grate bottoms are delivered from transfer trucks 6 to elevated tracks 2. The cars 10 successively pass under the ore

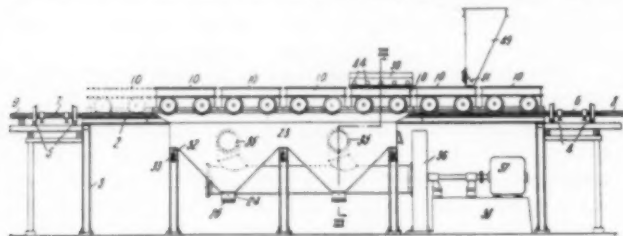


FIG. 2—SINTERING APPARATUS

hopper 49, receiving a charge of material to be sintered, thence into the furnace 39 where the top of the charge is ignited by means of gas or oil burners. On entering the furnace the cars register also with the suction box 23 placed below the tracks and connected with a fan 36 operated by a motor 37. While passing over the suction box the ignited charge is subjected to a downward draft, whereby the mass is sintered. When this operation is complete the car is delivered onto transfer truck 7 and removed to a point of discharge. No means is disclosed for mechanically moving the charge cars over the elevated track, nor for regulating the rate of travel. (1,140,710, May 25, 1915.)

### Gold and Silver

**Automatic Regulation of Pulp Thickening Apparatus.**—In the operation of such apparatus as the Dorr continuous thickener, in which overflow and under-

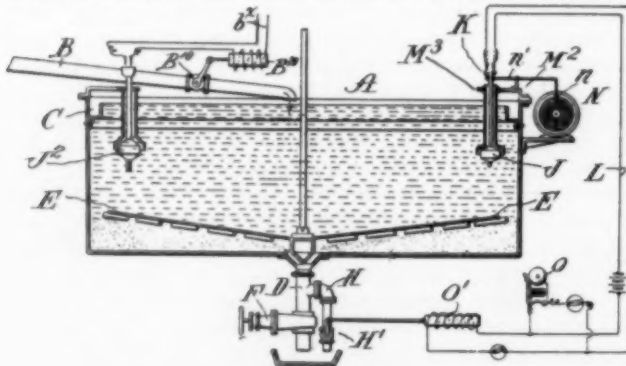


FIG. 3—REGULATION OF PULP THICKENING

flow products of certain character are sought, it is desirable that the apparatus should be operated in a uniform manner. With this object in view, Mr. J. V. N.

DORR of Denver, Col., has patented means for automatically giving warning when a change of density occurs in a selected zone of either product, and to regulate the discharge of the products for the purpose of maintaining constant conditions. Use is made of a hydrometer which rises and falls as the density of the liquid in a predetermined zone varies, and which may be made to operate mechanism to sound an alarm or regulate the apparatus, or both. The idea is illustrated in Fig. 3, applied to a Dorr thickener. A hydrometer *J* is adapted to close an electric circuit when the density of the liquid in a certain zone varies, and this circuit includes a bell or other alarm and a solenoid operating a discharge cock for the settled material. Recording apparatus *N* can be used by attaching a pen *n* by lever *n'* to the hydrometer. A similar hydrometer *J'* can be made to operate a cock on the feed line *B* by means of

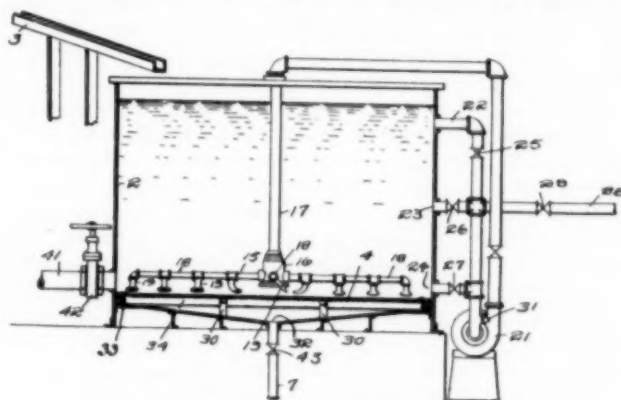


FIG. 4—FILTRATION OF SLIME

the solenoid as shown in the diagram. (1,140,131, May 18, 1915.)

**Apparatus for Cyaniding Slime.**—A method of treating slime pulps and separating the metal-bearing solution from the valueless gangue by filtration without forming a filter cake, is patented by Mr. ALBERT E. VANDERCOOK of Alameda, Cal. Interest attaches to the process inasmuch as it is reported that it is to be adopted at two properties in California and Nevada. One of the mechanical features is illustrated in Fig. 4, being a vat in which the treatment and the filtration take place.

The vat has a filter bottom and is connected with a source of vacuum not shown. Within the vat is a distributing pipe and nozzles through which the slime pulp is forced by the centrifugal pump 21. The pump has three connections with the vat at 22, 23, 24, either one of which can be used while the others are closed. In operation the vat is filled with pulp which is circulated by the pump through the pipes and nozzles. The streams of pulp issuing from the nozzles sweep the filter surface and keep it free from accumulations. Filtration proceeds without the formation of a cake, and when the filterable liquid is practically removed and a thick pulp remains, wash solution or water is added through pipe 28.

The pulp is again thoroughly mixed and filtered as before. The operation may be repeated and the final thick pulp is sluiced out through pipe 41. (1,139,825, May 18, 1915.)

### Smelting Process

**Recovery of Elemental Sulphur.**—A process for so operating smelting furnaces as to prevent the escape of noxious fumes, principally  $SO_2$ , and the production of elemental sulphur, is patented by Messrs. WILLIAM F. LAMOREAUX and CHARLES W. RENWICK of Isabella, Tenn. The process is based on the reduction of  $SO_2$  to sulphur



by means of carbon, and consists in passing the smelter fumes through an incandescent mass of coke. The electric current is used to heat the coke to the proper temperature and maintain uniform conditions. The temperature produced by the combustion of the coke alone in an atmosphere of sulphur compounds will not suffice to produce the reactions, as the product of combustion will mix with the smelter gases and vitiate the results. Hence the coke is heated electrically. The conversion from  $\text{SO}_2$  to S depends on the temperature and length of time of contact with the coke. A temperature of 1300 deg. C. and a period of contact of five seconds accomplishes practically 98 per cent reduction. (1,140,310, May 18, 1915.)

Another process for accomplishing a similar purpose is patented by Mr. WILLIAM A. HALL of New York City. The reduction of  $\text{SO}_2$  to S is accomplished in the smelting furnace by maintaining the top in as cold condition as practicable, by introducing continuously fresh ore to be smelted and by spraying the top of the ore with water. A portion of the water descends to a point where it is converted into steam, which reacts with the sulphide ore to form  $\text{H}_2\text{S}$ . This combines with the  $\text{SO}_2$  present in the gases to form water and elemental sulphur, the latter being carried out in the gases and recovered in washers. (1,133,637, March 30, 1915.)

#### Metallurgical Furnaces

An improvement in hearths in roasting furnaces of the McDougal type is claimed in a patent to Messrs. JOHN H. KLEPINGER of Great Falls, Mont., and FRANK R. CORWIN of Douglas, Ariz. Instead of forming the hearths of numerous molded forms of refractory material, a monolithic structure of reinforced concrete is formed for each hearth. The construction is practically free from joints and uneven surfaces which, in the usual furnace, tend to weaken the hearth and increase the growth of accretions of fused particles. (1,140,042, May 18, 1915.)

The effective heating of the hearth of a roasting furnace by means of an electric current is the basis of a patent granted to Mr. UTLEY WEDGE of Ardmore, Pa. In a nine-hearth furnace, in which hearths 1, 3, 5, 7 and 9 are fixed, and 2, 4, 6 and 8 rotatable, electrical heating devices are applied to hearths 3, 5 and 7. Each of these hearths has sector-shaped recesses or chambers for the reception of electrical resistance blocks. Each recess is closed at its top to provide a continuous upper surface for the hearth, but is open below for the radiation of heat from the resistance block directly upon the material carried by the hearth beneath. (1,137,559, April 27, 1915.)

**Sulphur Burner.**—The Valley Iron Works Company, Appleton, Wisconsin, is now prepared to furnish the Vesuvius sulphur burner for producing pure sulphur dioxide gas in nine sizes from laboratory size to 9-ton capacity.

The Clarage Fan Company, Kalamazoo, Michigan, have opened a Cleveland sales office in the Rockefeller Building, Cleveland, Ohio. This office is in charge of Mr. R. G. Ferguson.

The U. S. Blow Pipe & Dust Collecting Company is the new name of the former U. S. Steel Tank & Pipe Co., exhaust-system contractors of 2090 Canalport avenue Chicago, and 3000 N. Ninth street, St. Louis, Mo. The new name is more representative of their ever-growing business in shaving and fine dust collecting for woodworking, grain elevators, mills and all industries where dust and refuse are created.

Ore from the Boss mine, near Goodsprings, Nevada, containing the platinum group of metals, has been

shipped to the American Smelting & Refining Co., according to a bulletin from the Mackay School of Mines. The shipment weighed 56,267 pounds and assayed as follows: Platinum, 1.1 oz. per ton; palladium, 5.47 oz.; gold, 8.75 oz.; silver, 9.0 oz.; copper, 0.97 per cent; insoluble, 80.7 per cent; sulphur, 0.5 per cent; iron, 6.7 per cent.

#### Welding Up Scrap Nickel Anodes

Some interesting experiments in the welding of nickel anodes by the oxy-acetylene process have just been concluded in the large plating department of The Prest-O-Lite Company, Inc., at its Indianapolis plant. As a result of these experiments and tests, worn nickel anodes which have previously been scrapped and sold at less than half price are now being reclaimed at a saving of more than 100 per cent.

The anodes used by The Prest-O-Lite Company, Inc., are castings of 90 per cent nickel, 8 per cent carbon and 2 per cent iron. They are elliptical bars approximately  $1\frac{1}{2}$  in. x  $3\frac{1}{2}$  in. cross section and 30 in. long and weigh about 30 lb. Their market value varies between 46 and 50 cents per pound. On the basis of the latter price, each 30-lb. anode has a value of \$15.

By welding up old anodes which have been in the solution, and which have a junk value of between 22 and 25 cents per pound, The Prest-O-Lite Company, Inc., is now converting its entire pile of scrap nickel into what are practically new anodes at a total cost for gas



FIG. 1—SCRAP NICKEL ANODES WELDED TOGETHER

and labor of less than 6 cents per pound. This estimate is based on a recent test at Indianapolis in which 421 lb. of scrap anodes were welded up at the following costs:

463 cu. ft. oxygen, at 2 cents.....	\$9.26
480 cu. ft. acetylene, at 2 cents.....	9.60
24 hours labor, at 25 cents.....	6.00

Total ..... \$24.86

In view of the fact that this test was made before any experience in the operation had been gained, it is

apparent that better results and greater savings are sure to be the result of practice.

The method of handling this operation is as follows: As the anodes are eaten away by the solution they are turned over to an oxy-acetylene welder who "tacks" on scraps of old anodes by welding to increase the surface. One, two, three and sometimes four pieces of scrap are welded on, depending on the size and weight desired.

The welding flame is also employed to remove the brass hooks which are used to support the anodes while in solution. Under the intense heat of the oxy-acetylene flame (approximately 6,300 deg. F.) the solder melts away rapidly, leaving a pure nickel bar which is later welded up.

Thus, by the addition of from, say, 5 to 15 lb. or more of scrap nickel a brand new anode is manufactured at trifling cost and every bit of scrap is utilized without the loss of a single pound of metal. No flux is employed as this has been found to be unnecessary. The pieces of scrap are simply melted on or "fused" together, using another piece of nickel as a filling rod.

The welding process is a great benefit in obtaining perfect fusion, which is essential, as all joints must have electrical conductivity equal to that of new anodes.

Another great advantage is the fact that no skill or experience in the art of oxy-acetylene welding is required to weld up scrap nickel anodes—in fact, any workman with average intelligence can do the work without any previous knowledge of the process. The apparatus required to do the work is inexpensive.

Many previous attempts have been made to utilize scrap nickel anodes, the most common practice being to drill holes through several pieces and bind them together by means of lead rivets. This method depends upon the contact of the wire or rivet and the piece of scrap to conduct the current, and is therefore of uncertain value and in many cases a flat failure. If, for any reason, the contact is bad and offers too much resistance to the current of electricity, the metal might or might not dissolve. Therefore, by using the welded anodes as much scrap may be used in a tub as is desired without any danger of depleting the solution of metal.

The welding process solves an important problem in the nickel plating industry as hundreds of tons of scrap nickel anodes can now be utilized at the same value as new anodes and at trifling cost.

The Prest-O-Lite Company, Inc., estimates that more than a ton a year of scrap anodes can be used in its plating department.

## The Course in High Temperature Measurements at Purdue University

BY ERVIN S. FERRY

Head of the Department of Physics.

Some half-dozen years ago the Department of Physics of Purdue University commenced the organization of a course in high-temperature measurements. The lack of standardization of equipment, as well as the lack of a text book or laboratory manual, necessitated a large amount of work preliminary to the admission of students. Much of this preliminary work was done by Dr. G. A. Shook, now of the University of Michigan. Since the departure of Dr. Shook the laboratory work of the course has been under the charge of Instructor J. R. Collins. As the course has emerged from the pioneer stage and now forms part of the required work of the students in our school of chemical engineering, it has been thought that a brief description would not be without interest to readers of *Metallurgical and Chemical Engineering*.

The course occupies one hour of lecture and five hours of laboratory work per week for one-half year. The lectures begin with a consideration of the ideal gas, the thermodynamic and the black-body temperature scales. Then follows a consideration of thermoelectric and resistance pyrometry. The methods of making the "cold-junction correction" as well as the practical means employed to diminish the magnitude of the error are discussed in some detail. The laws of radiation are taken up and discussed with especial reference to optical and radiation pyrometry. The methods of calibrating and using all the standard types of pyrometers are studied, as well as the availability of the various types for particular duties.

The furnace equipment includes three 20-kw tube furnaces, each connected to a separate transformer and switchboard (Fig. 1), a number of smaller electric



FIG. 1—TUBE FURNACES

furnaces, and a battery of five gas furnaces for 1-gal. crucibles (Fig. 2). Through the courtesy of the professor of practical mechanics our students also use the large oil furnaces belonging to that department. The laboratory maintains a Lummer-Kurlbaum "black-body," which, however, is no longer entrusted to student use.

The instrument equipment includes several types of thermoelectric pyrometers; resistance pyrometers having various types of bridges and potentiometers; radiation pyrometers according to Fery and Thwing; together with optical pyrometers according to Le Châtelier, Fery, Shore, Wanner and Holborn-Kurlbaum.

The list of experiments for the present year includes the ten determinations outlined below, followed by prac-



FIG. 2—GAS FURNACES

tical temperature determinations under shop conditions in the tempering room of the department of practical mechanics.

1. *Calibration of a Platinum-Rhodioplatinum Thermoelectric Pyrometer.*—The empirical curve is constructed by coordinating the known freezing points of five metals



or salts with the corresponding pyrometer indications. The equation of this curve is computed and the curve extrapolated.

**2. Construction and Test of a Base Metal Thermoelectric Couple.**—The two wires are wound with asbestos, coated with fireproof insulating material, the "fire end" fused, the wires annealed and tested for inhomogeneity. The calibration is made by comparison with a standardized platinum-rhodioplatinum couple. To exercise the student in making "cold-junction corrections" the cold junction of the standard thermoelement is maintained at a temperature different from that at which it was calibrated. The calibration curve of the standardized thermoelement is computed for the particular temperature of the cold junction at the time of the experiment. From this curve and the readings obtained from the base metal pyrometer the calibration curve of the latter is constructed. The ordinary approximate shop methods of correcting for the cold junction temperature are compared with the more precise method.

**3. Determination of the Transformation Points of a Specimen of Steel.**—For this experiment a device has been developed that will permit the location of not only the decalescent and incalescent points, but also the points of less marked absorption or evolution of heat.

**4. Calibration of a Resistance Thermometer.**—Both potentiometer and bridge indicators are used. From the indications at three known boiling points is computed the relation between temperature and resistance. From this equation the calibration curve is constructed.

**5. The Direct Calibration of a Pyrometer by Means of a "Black-Body" and a Standardized Thermoelement.**—The Fery lens radiation pyrometer, the Fery mirror radiation pyrometer, the Fery spiral radiation pyrometer, the Thwing radiation pyrometer and the Shore pyroscope are calibrated by a step-by-step direct comparison with a standardized thermoelement.

**6. Calibration of a Le Chatelier Optical Pyrometer.**—From the theory of the instrument and the observation of a "black body" at one known temperature a complete calibration curve is constructed. This is compared with the curve obtained by a step-by-step comparison of the optical pyrometer readings with the thermoelectric pyrometer readings of a "black-body" at a series of temperatures.

**7. Calibration of a Wanner Optical Pyrometer.**—A calibration curve is constructed based on the reading obtained when directed toward a "black-body" at one known temperature, and this curve is compared with the calibration curve obtained from observations on a body at a series of known temperatures.

**8. Calibration of a Holborn-Kurlbaum Optical Pyrometer.**—From the observations on a body at three known temperatures the equation of the calibration curve is computed. The curve obtained from this equation is compared with the calibration curve obtained from a series of known temperatures.

**9. The Determination of the Relation Between the Luminous Intensity and the Temperature of an Incandescent Lamp Filament.**—In this experiment a curve is obtained coördinating the temperature of the filament and the current traversing it, and also a curve coördinating candle power and current. From these two curves the required curve showing the relation between candle power and temperature is constructed.

**10. Calibration of a Fery Absorption Pyrometer.**—From the readings obtained when directed toward a "black-body" at two known temperatures the equation of the calibration curve can be found. The curve obtained by means of this equation is compared with one obtained from observations of a body at a series of known temperatures.

As in the other laboratory courses of the department of physics at Purdue University, before a student begins an experiment in this course he must write an analysis of the experiment which shall include the derivation of all equations used, the method of making the computations and an outline of the laboratory procedure. After completing the required observations he tabulates the data, makes the necessary computations, constructs his curves, and writes the laboratory report.

The analysis, the experiment, the computation and the report are all done under class-room conditions, without book, notes or any other assistance than that which may be given by the supervising instructor. This practice results in efficient preparation on the part of the student and a low laboratory maintenance cost on the part of the department.

### A New Diaphragm Pump

The Colorado Iron Works Company of Denver, Col., has brought out a diaphragm pump which is felt to

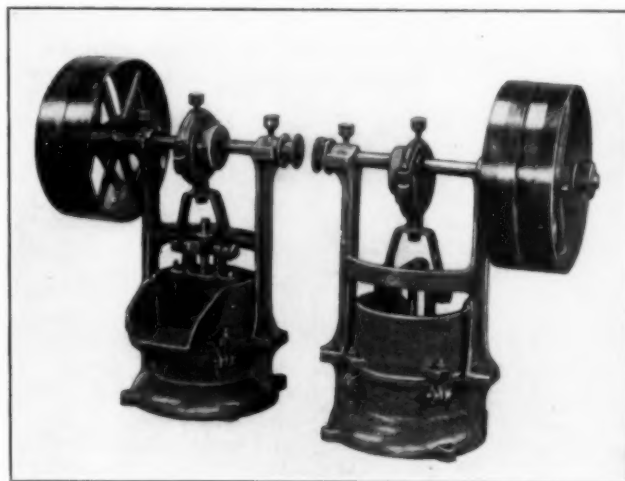


FIG. 1—NEW TYPE OF DIAPHRAGM PUMP

meet the requirements of handling slime in cyanide plants and similar work, and at the same time offers important advantages in the matter of convenience. The pump is illustrated in Figs. 1 and 2.

In ordinary power-driven diaphragm pumps, the power is applied through a rocking motion which causes

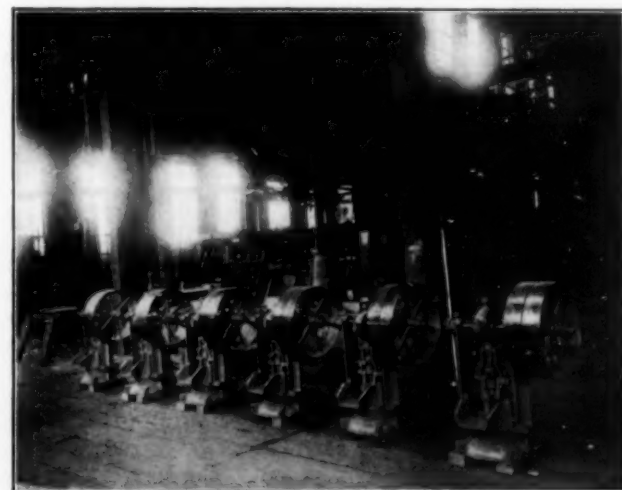


FIG. 2—DIAPHRAGM PUMPS ON ASSEMBLING FLOOR

rapid deterioration and failure of the diaphragm. In the pump under consideration this disadvantage is overcome by the use of an eccentric and cross-head working

in a guide. While this greatly increases the life of the diaphragm, yet to facilitate its replacement without disturbing the driving mechanism, the pitcher spout portion which holds the diaphragm in place can be raised for removal of the ruptured diaphragm and insertion of the new one. Hook bolts are here used to eliminate all possibility of dropping them or their nuts, possibly into a tank full of pulp.

Recognizing the advantage of a pump which will deliver the material at a uniform rate, this one is fitted with adjustable eccentrics such as used on jigs, whereby the length of stroke can be adjusted within a wide range to suit the desired volume, without changing the speed.

The pump is made with 3-in. and 4-in. suction, uses standard diaphragms and can be had with either side or bottom suction. While being a suction pump and consequently subject to limitations as to lift imposed by altitude and the density of pulp, it nevertheless has sufficient lift for most applications, and where it applies it offers probably the most satisfactory means obtainable.

### British Producer-Gas and Ammonia-Recovery Plant

London *Engineering* of June 4, 1915, contains an interesting description of the producer-gas and ammonia-recovery plant developed by Mr. ARTHUR H. LYMN of

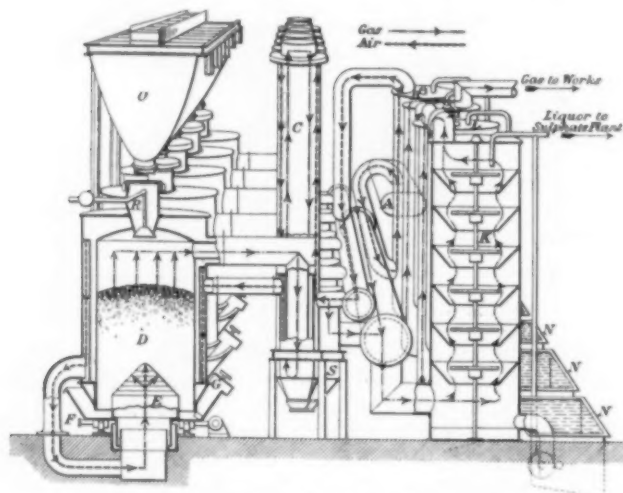


FIG. 1—DIAGRAM OF CYCLE OF OPERATIONS

Sanctuary House, Tothillstreet, Westminster. Although of British origin, the Lymn system has had some of its most important applications in Germany. During the two years immediately preceding the war, contracts for Lymn plants having a total value of about \$500,000 were secured in Germany.

A perspective diagrammatic sketch of a Lymn plant is given in Fig. 1. In a general way it is based upon the Mond process, the essential patents of which have expired. The Lymn apparatus, however, has many features peculiar to itself, and in connection with these various advantages are claimed, as, for instance, low first cost, smallness of space occupied, and simplicity of operation. The plant is automatically regulated, and is capable of using a large range of fuels. It is stated that by-products can be profitably recovered in units as small as 500 horsepower. The special features of the Lymn producer and recovery plant are largely concerned with the ammonia-absorption, gas-washing, gas-cooling and air-saturating arrangements, the common high and bulky towers having been replaced by a novel system of vertical washers, in which the washing

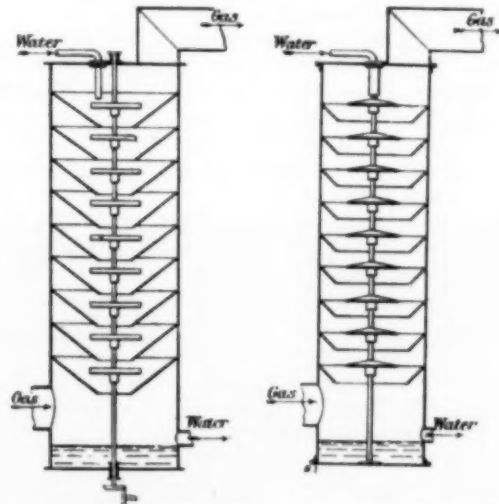
of the gas is chiefly brought about by its own momentum.

The cycle of operations, about which there is little novel, will best be followed by reference to Fig. 1, where D is the gas-producer, E the grate and F the water seal. This seal allows ashes to be removed from the grate by the apparatus G without interfering with the working of the producer. This operation is performed automatically or manually, depending on whether the grate is mechanical or non-mechanical. Above the producer there is an overhead fuel banker O, feeding to a charging-hopper R.

In Fig. 1 the heavy dotted lines represent the path of the air, and the dot-and-dash lines the path of the gas. The arrows on these lines indicate the direction of flow at various points. It will be seen that the air and steam blast enters the fuel in the producer through the grate; before dealing with this point in the cycle, however, it will be well to trace back the air stream to its point of origin at the blower A.

The blower is of the Roots, or some such type. The air from the blower first passes through the air-saturating apparatus B, in which it is brought into intimate contact with hot water and becomes saturated with steam. The water is heated during the cooling of the gas at a later point of the cycle. The saturating apparatus B will be described in detail later. From the saturating apparatus the air passes to the superheater C, in which it is superheated by the hot gases from the producer. The air and gases pass through the superheater in opposite directions. From the superheater the air and steam mixture may pass through the jacket of the producer, through the grate, and into the fuel bed. It is further heated in passing round the producer through the jacket.

We may now deal with the path of the gases, which as they leave the producer carry with them the ammonia and other constituents, which are afterwards recovered as by-products. The hot gases first pass to the superheater, where, in heating the stream of air and steam, they part with much of their heat, which is thus



FIGS. 2 AND 3—CONSTRUCTION OF MECHANICAL WASHER AND COOLER

recovered and returned to the producer. From the superheater the gases pass through a dust-separating apparatus S to the ammonia-absorber K. In this absorber the gases are brought into intimate contact with an atomised solution of sulphate of ammonia containing a small excess of sulphuric acid. The acid dissolves the ammonia in the gases, and the solution passing to the bottom of the absorber enters the tanks N. From the absorber the gases pass to the gas-cooler L, which is



an apparatus of the same type as the absorber. Here they are brought into intimate contact with cold water. This gas-cooler works in a cycle with the air-saturator, B, which has already been referred to in connection with the path of the air. The water first passes through the gas-cooler, thus cooling the gas and at the same time itself becoming heated. It then travels to the saturator, and saturating the air, is itself in turn cooled, and is then ready for a further passage through the gas cooler.

By the use of this cycle it is clear that a large amount of heat, which would otherwise be wasted, is recovered from the gas and returned to the producer as steam. On leaving the gas-cooler L, the gases pass to a second cooler M, where they are again brought in contact with cold water. Leaving this they are sufficiently clean and cool for firing boilers or furnaces, but if they are to be

entering at the bottom, passes up through the finely-divided spray and is cooled, or, in the case of the absorber, has the ammonia it is carrying dissolved out. This type of mechanical washer or cooler is not novel, but Mr. Lymn is believed to have been the first to apply it to producer-recovery plants. Originally he designed his coolers on traditional lines, but on watching their operation he came to the conclusion that the momentum of the gas was a more important agent in the mechanical mixing than the rotation of the discs. Accordingly, he cut away a considerable part of the collecting cones to give the gas more play, and finally he was able to handle the gas from 90 to 100 tons of coal in a cooler which was traditionally designed to handle the gas from 45 to 50 tons.

This work ultimately led to the type of construction shown in Fig. 3. In this it will be seen that the holes

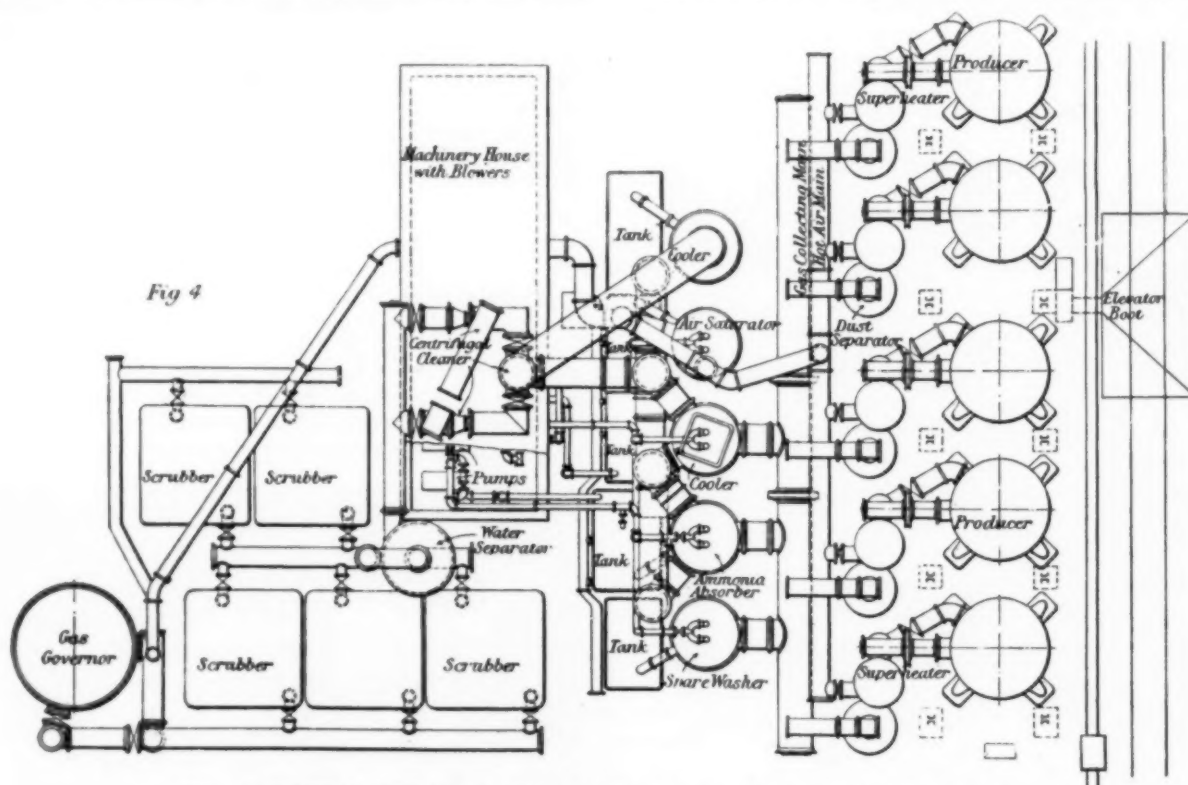


FIG. 4—GENERAL OUTLAY OF PRODUCER-GAS AND AMMONIA-RECOVERY PLANT

used in gas engines they have still to be treated for the removal of tar. This process is carried out in centrifugal cleaners and dry scrubbers of the usual type. The sulphate of ammonia is recovered by evaporation of the solution collected from the ammonia-absorber by the tanks N. The solution is circulated through these tanks and through the absorber until it is very concentrated, when but little evaporation is required for crystallizing out the solid salt.

The design of the saturator B, the absorber K, and the gas-coolers L and M undoubtedly forms one of the most interesting features of this plant. It is indicated to some extent in Fig. 1, but may be more clearly explained by reference to Figs. 2 and 3. Referring first to Fig. 2, it will be seen that the arrangement consists of a vertical cylindrical chamber, containing a series of inverted truncated cones. Up to the middle of the chamber a shaft runs, carrying a number of discs. The shaft is rotated by gearing at the bottom end. The water enters the cooler at the top, and falling onto the first rotating disc is sprayed onto the surrounding cone. From this it falls onto the next disc, to be sprayed to the succeeding cone, and so on. The gas,

in the bottom of the cones are of considerably larger diameter than the discs, so that if no gas is passing water entering the top falls straight to the bottom. So important has the effect of the momentum of the gas proved to be in this form of cooler that in the design shown in Fig. 3 it has been found possible to do away with the rotation of the discs altogether, and plants have now been in successful operation for more than two years with fixed discs. The importance of these improvements, which have doubled the capacity of the coolers, and at the same time simplified them, is obvious. The capital outlay is largely reduced and space is saved. Coolers of the type shown in Fig. 3 can be built to deal with gas from 10,000 cu. ft. an hour to 1,300,000 cu. ft. an hour in a single unit. It should, perhaps, be said, as will probably be obvious, that the dimensioning of these coolers is not altogether a simple matter, and that they are designed empirically from data built up from practical experience.

In connection with other parts of the gear it may be said that considerable pains have been taken to apply to these ammonia-recovery plants the mechanical agitation of the fuel and ash zones of the producer, as well

as mechanical ash removal, which have been so widely applied to ordinary gas-producers in Germany. The producer is based on the principle which has been so largely utilized for hot-gas producers, and involves a rotary grate and mechanical ash removal somewhat on the lines introduced by Kerpely of Vienna, and others. Adapting a hot-gas producer for ammonia-recovery conditions, Mr. Lymn has naturally found material modifications necessary, owing to the greatly increased volume of air and steam, the deeper fuel-bed, the necessity for superheating the blast of air and steam, etc. An interesting point in connection with this plant is that it contains no lead parts. Steel is used for the ammonia-absorbing apparatus. In a plant which has been in operation in Germany for four years, and which contains no lead whatever, no corrosion has been found. A plan showing the general lay-out of a Lymn plant is given in Fig. 4. The functions of the various parts will be followed in connection with the sketch of the method of operation we have already given.

Among the various plants in operation in Continental Europe, *Engineering* mentions one belonging to the Badische Anilin und Soda-Fabrik at Ludwigshafen, and another belonging to the German government at Heinitz, and a plant of six producers built for firing steel furnaces at the Barop Steel Works.

In Table I the actual operating results are given for a Lymn plant over two periods of four weeks each.

TABLE I—OPERATING RESULTS OF POWER-GAS PLANT (LYMN SYSTEM), DRIVING LARGE GAS-ENGINES AND FIRING FURNACES

This plant was designed to gasify 45 to 50 tons of coal per 24 hours. It has since been extended, and is now gasifying about 80 tons, and is driving four 1300-hp gas-engine electric sets, and also firing four furnaces. The coal in use is small, through a  $\frac{3}{4}$  in. sieve, and ordinary brown-coal briquets. Average price, 12 to 13 marks (\$3 to \$3.25) per ton.

FIRST PERIOD, BETWEEN NOVEMBER 20 AND DECEMBER 22, 1912 (FOUR WEEKS)

	Total	Average per day of 24 Hours	General Average
Coal consumption of the gas plant.....	1806 tons	64.6 tons	0.72 kg. per kw-hr.
Power produced (kw-hr.).....	1,889,740 kw-hrs	.....	2812 kw-hours per hour
Yield of sulphate of ammonia.....	49.11 tons	1.76 tons	27.1 kg. per ton of coal
Yield of tar (containing water).....	189.7 tons	6.78 tons	105 kg. per ton of coal
25 per cent of total gas produced is used for firing furnaces.			

Average heat value of the gases, 1380 calories per cubic meter (155 B.t.u. per cubic foot).  
Tar contained in the gas (average), 0.04 gram tar per cubic meter.  
The auxiliary machines (excluding blowers) consumed regularly 71 kw.  
Including 10 per cent depreciation, the gas costs per kw-hour work out at 0.55 pfennig (0.138 cent).

SECOND PERIOD, BETWEEN JANUARY 27 AND FEBRUARY 23, 1913 (FOUR WEEKS)

	Total	Average per Day of 24 Hours	General Average
Coal consumption of the gas plant.....	1967 tons	70.2 tons	0.78 kg. per kw-hr.
Power produced (kw-hr.).....	1,909,600 kw-hr.	.....	2830 kw-hours per hour
Yield of sulphate of ammonia.....	54,300 kg.	1.94 tons	27.6 kg. per ton of coal
Yield of tar (containing water).....	231,700 kg.	8.27 tons	117 kg. per ton of coal
25 per cent of total gas produced is used for firing furnaces.			

Average heat value of the gases, 1370 calories per cubic meter (154 B.t.u. per cubic foot).  
Tar contained in the gas (average), 0.057 gram per cubic meter.  
The auxiliary machine (excluding blowers) consumed regularly 78 kw.  
Including 10 per cent depreciation, the gas costs per kw-hour work out at 0.56 pfennig (0.14 cent).

#### NOTES

1. Nitrogen contained in the coal (average), 0.8 per cent.
2. Heating value of the coal, 6000 kg. cal. per kg. (10,400 B.t.u. per lb.).
3. The nitrogen efficiency during these two periods was 70 per cent. It is frequently 75 per cent.

The periods are not specially selected. It will be noted that in spite of the low nitrogen content of the coal and its high price the cost of gas per kilowatt-hour worked out at only 0.14 cent.

There is one point in connection with this branch of

industry which deserves considerable attention. The amount of steam generally used by these plants is about  $2\frac{1}{2}$  tons for every tone of coal gasified. Of this amounts up to two-fifths, or 1 ton per ton of coal gasified, is recovered from the heat of the gases in a modern plant. This steam is recovered during the gas-cooling and air-saturating cycle. The remainder has to be raised either by means of direct coal-fired boilers or in some other way. Needless to say, the employment of special coal-fired boilers involves a considerable charge on the operating costs of the plant, and the alternative of utilizing waste heat from gas engines, furnaces, etc., to raise such steam offers considerable attractions. In the plant referred to in Table I, which has been in operation for four years, the whole of the steam is raised in this way. There are four boilers, each attached to a 1300-hp gas engine. They raise 2 lb. to  $2\frac{1}{2}$  lb. of steam per horsepower-hour. The steam produced is quite 25 per cent in excess of that required for the gasification of the coal. Corrosion is sometimes mentioned as a difficulty in connection with this form of application, but in Mr. Lymn's opinion the matter is purely one of properly dimensioning the boilers. The plant in question has been in day and night operation for four years without any trouble from this cause. It is stated that this plant was the first in existence absolutely self-contained in the matter of steam supplies.

### Exhibits at the San Francisco Exposition Carborundum Exhibit

Prominent among the exhibits in the Palace of Machinery is the display of The Carborundum Company, Niagara Falls, N. Y. The accompanying illustrations give some idea of the attractiveness of the display,



FIG. 1—CARBORUNDUM EXHIBIT

embodying a grand idea of broad industrial education.

In brief the plan of the exhibit is to show the varied uses to which carborundum products are put, to show the wide variety of materials and products in their crude or unfinished state and after they had been cut, ground or finished with carborundum products. The result has been a wonderful collection gathered from manufacturing plants, not only in this country, but from South America, England, India, New Zealand, Australia and other foreign countries. The collection embraces materials and products ranging from tooth picks to flooring, from flour mill rolls to needles, from steel shafts to watch dials, from semi-precious stones to shrapnel shells and malleable castings, and also includes samples of marble, onyx and granite, pearl, cut



and engraved glass, sueded skins and boots and shoes. In the grinding, shaping and finishing of every piece of the show, carborundum products have played their important part, and in each case the particular carborundum product which did the work is shown.



FIG. 2—CARBORUNDUM FOUNTAIN

To display the hundreds of products, a space of about 1400 square feet was necessary. The materials are shown in full glass show cases (Fig. 1). In the center of the exhibit is a fountain (Fig. 2), built of irregular masses of iridescent carborundum crystals, over which real water plays, splashing into a marble basin, the coping for which was moulded with carborundum wheels. The fountain is twelve feet high and is strikingly beautiful.

#### Cork Exhibit—Heat-Insulating Materials

Industrial education is also the keynote of the joint display of the Armstrong Cork Company and the Armstrong Cork & Insulation Company of Pittsburgh, Pa.

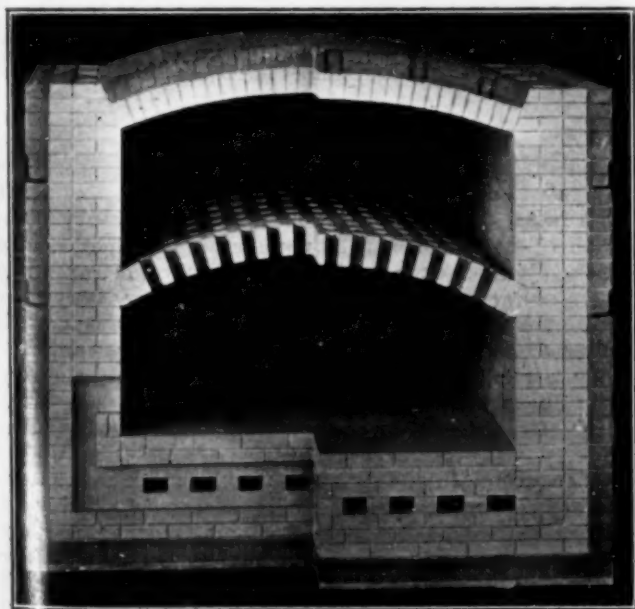


FIG. 3—HEAT-TREATING FURNACE INSULATED WITH NON-PAREIL BRICK. MODEL AT SAN FRANCISCO EXPOSITION

The exhibit is situated at the corner of Sixth Street and Avenue A in the Palace of Manufactures and occupies a space 26 by 40 ft. No attempt whatever was

made to have a "big" display. Emphasis rather has been placed on perfection of detail. The pavilion itself reflects this idea.

Entering it from the Sixth Street side, the first thing that attracts the visitor's attention is the display of corks and cork specialties. Here may be seen pieces of "virgin cork," "second stripping bark," and a number of specimens of the third and subsequent strippings (cork being really the outer bark of a species of evergreen oak which flourishes only in the Spanish Peninsula, Southern France and Northern Africa). Some of the sheets are of exceptional size, others of unusual thickness. A cross-section of a cork tree is also on display, showing the dense, heavy wood of the trunk, the thin inner bark—which is the seat of the growing processes, and the thick outer coating of cork.

Attractively arranged in ninety-five glass jars are corks of every kind and description and for any kind of service. In a show case are exhibited an amazing array of cork specialties.

Of greatest interest to our readers, however, will be the exhibit of heat-insulating materials. All of these articles exhibited, except one, are by-products of cork

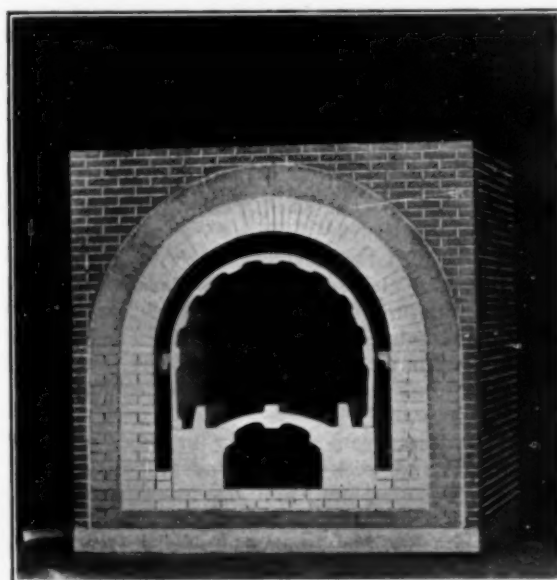


FIG. 4—MUFFLE FURNACE INSULATED WITH NON-PAREIL BRICK. MODEL AT SAN FRANCISCO EXPOSITION

—manufacture either solely, or in part, from cork waste. The one exception is "nonpareil" high-pressure covering for steam lines and other heated surfaces, which is composed of diatomaceous earth (kieselguhr) and asbestos.

The most important of this group of products is nonpareil corkboard, for insulating cold-storage warehouses, ice factories, packing plants, breweries, dairies, creameries, fish freezers, fur storage vaults, refrigerators, etc. The principal steps in this manufacture are shown by suitable specimens, and few visitors are not surprised to learn that the particles of cork waste are held together solely by the natural gum or rosin which is brought out by the manufacturing process.

Of somewhat similar interest is the display of nonpareil cork pipe covering for brine, ammonia and drinking water lines. Some idea of its commercial importance may be gathered from the fact that this product is manufactured in more than 1500 different shapes, sizes and grades.

The exhibit of nonpareil insulating brick, which adjoins that of cork covering, is an unusual demonstra-

tion of how modern science produces new articles by combining two or more substances long well known. These insulating brick—so light that they float on water—are composed of diatomaceous earth mixed with ground cork, molded into brick form and then fired. The cork is burned out entirely, leaving the brick extremely porous in texture and a light terra cotta in color. A series of nine models, complete in every detail, show how the brick are installed in boiler settings, bread baking ovens, heat treating furnaces, hot blast mains, brick kilns, etc., to save fuel. Their remarkable heat-insulating efficiency, moreover, is demonstrated by an electrically-heated furnace, which is maintained constantly at a temperature of 1000° F.

But the most interesting feature of the display of heat insulation is a cross-section of a typical cold storage plant, built to scale and complete in every respect. In this model, which is 7 ft. 4 in. wide and 7 ft. high, the commercial installation and use of the entire line of nonpareil heat insulating materials are effectively demonstrated. For example, the boiler is insulated with miniature nonpareil insulating brick, the steam lines and feed water heater are covered with nonpareil high-pressure covering, the brine and ammonia pipes are covered with nonpareil cork covering, while the brine cooler, ammonia accumulator and fore-cooler are insulated with nonpareil cork lagging. The second, third and fourth stories of the model include an ice freezing tank, ice storage, and meat, butter, fruit and egg storage rooms—all insulated with nonpareil corkboard. Miniature tubs of butter, barrels of fruit, crates of eggs and sides of meat add a finishing touch of reality to the whole structure.

A motor-driven fan a few yards away, which serves to demonstrate the sound, and vibration absorbing value of nonpareil cork machinery isolation is the next thing that usually catches the attention of the visitor. This material is used under fans, motors, pumps, printing presses and other machinery to deaden noise and diminish vibration.

Other exhibits are cork paving brick (a combination of finely ground cork and asphalt), cork tilings for museums, libraries, etc., and the linoleum department, powdered cork being the basic ingredient of linoleum.

#### Mining Exhibits

The Mines and Metallurgy Departmental Jury of the Panama-Pacific Exhibition has adopted unanimously the following resolution:

*"Resolved, That the Mines and Metallurgy Group Jury of the International Jury of Awards of the Panama-Pacific International Exposition desires to convey to the administration of the exposition and to the exhibitors in the Mines Department an expression of its high appreciation of the service which has been rendered to the mining industry and of the stimulus which has been given to the wise development of the world's mineral resources by the exhibit in this department. The jury heartily congratulates the chief of the department of mines and metallurgy, Prof. Charles E. van Barneveld, on the great success of the exhibit.*

*"Taken collectively, the exhibit displays a remarkable development in the method of presenting the mining industry for the general revise and education of the public. This development is not due so much to improvements in the individual methods of display, but rather to the adoption of a new point of view of planning and arranging the exhibit materials as a whole. The fundamental thought running through the entire exhibit is to set forth in a vivid and forceful manner the tremendous utility of our mineral resources. A systematic collection of the ores of the various metals and non-metals forms but the first step in a series of exhibits which demonstrate the basic importance of the mineral industry to civilization. The great variety of products derived from our mineral deposits shows in the most impressive manner the fundamental dependence of our industries upon the mineral supply.*

*"The results show great achievements in establishing step*

*by step the interdependence of mining and manufacturing, with special emphasis placed on the paramount necessity of safeguarding human life and conserving human energy. The results have greatly increased the popularity of the mining department and have made the building a rendezvous for the public as well as for the specialist.*

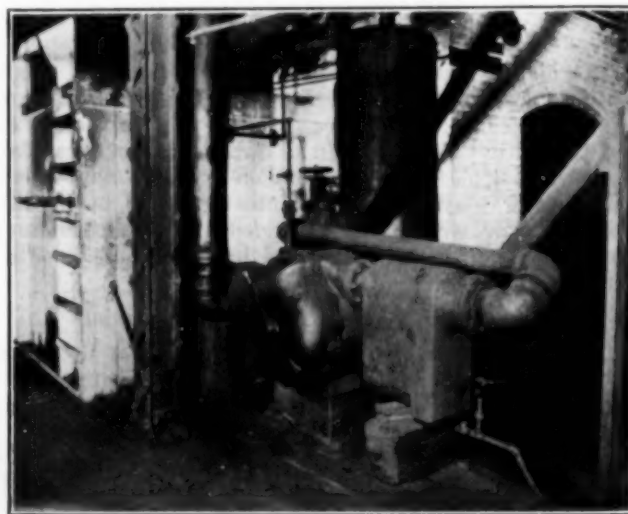
*"In general, the mining industry is so clearly depicted as to make this jury cordially urge the visiting public to profit by the educational opportunities offered by this department."*

\* \* \*

The International Jury of Awards, Panama-Pacific International Exposition, has voted to give a medal of honor to the publications of the McGraw Publishing Company, Inc., which include METALLURGICAL AND CHEMICAL ENGINEERING. This is the highest award granted a publishing company. The principal basis of the award is the general excellence and superiority of these publications.

#### Air Compressor

The accompanying illustration shows an illustration of an air compressor at work in the plant of the Nungesser Carbon & Battery Co., of Cleveland, Ohio. This air compressor has been in continuous use for over a year without giving any trouble since or putting the



AIR COMPRESSOR

company to any expense for repairs. It operates over its rated capacity. It is belt driven from a line shaft and takes 43 hp. It operates ten 6-inch air cylinders with 12-inch strokes at 20 pounds pressure per square inch. It also operates other auxiliary air for other purposes around the plant. As its continuous service is all-important for the main purpose for which it is used, since a shut-down would require stopping a considerable portion of the plant, the fact that it is running continuously without adjustment and with its original high efficiency, attaches considerable interest to its design.

The principle of this air compressor which was designed and built by the Nash Engineering Company, of South Norwalk, Conn., is radically different from every other device on the market for compressing air. Its only moving part is a rotor mounted on a shaft, well supported by bearings, and it is arranged to spin freely in an elliptical casing. The pump is filled with water. Power is applied to the end of the shaft, causing the rotor to revolve, which in turn carries the water around with it.

The water, in addition to turning with the rotor, follows the surrounding casing, due to centrifugal force.



As the hub and blades of the rotor are round, and the casing elliptical, it follows that a portion of the water alternately recedes from and reenters the rotor. When the water goes out of the rotor air is drawn in through ports cut in the sides of the casing. When the water is pushed back into the rotor, the water acting as a piston, compresses and delivers the air through the outlet ports.

The water stays at the level of the outlet ports and is used continuously. A small quantity of water is supplied to the compressor to absorb the heat of compression. This water enters at atmospheric pressure and is discharged with the air into a separator, which removes all entrained moisture from the air. The air is thus thoroughly washed of all dust and dirt and contains no oil, which is an advantage where clean air is desired.

There are no valves, gears, connecting rods or moving vanes. The bearings are very large and are relieved of side strains, due to the fact that compression takes place simultaneously on opposite sides of the rotor.

The delivery from these compressors is free from pulsation, therefore no receiver is required. The efficiency is high and the only attention they require is that they are occasionally lubricated and supplied with water.

### American-Made Porcelain Ware for Chemical Laboratories

New in the list of manufacturers of high-grade laboratory porcelain ware, but old and well known as a manufacturer of earthenware and porcelain (cooking utensils, etc.), is the Guernsey Earthenware Company of



PLANT OF THE GUERNSEY EARTHENWARE COMPANY

Cambridge, Ohio. It would be wrong, however, to assume that this company went into the manufacture of laboratory porcelain ware as a result of the European war, since, under the direction of its president and general manager, Mr. Charles S. Casey, it had been engaged in experimental work for two years preparing to place upon the American market a laboratory ware in every way equal to that of the imported article.

The clays which go into the makeup of Guernsey ware are both foreign and domestic, and it was the selection of these clays and various tests on various combinations of clays which occupied considerable attention during the experimental period. The result of these experiments has been entirely satisfactory, as all tests have shown that the porcelain is equal to any made in the world, as the company's guarantee reads.

The original pieces manufactured were crucibles, casseroles, evaporating dishes, mortars and pestles, Petri dishes. The demand for these pieces has already reached 2000 per day, and the factory is now being ar-

ranged to greatly increase the output both in variety and number, so that it will occupy a space of 200 x 420 feet. Additional ware which will soon be offered comprise beakers, porcelain plates, Rose crucibles, Gooch crucibles, funnels, spatulas, spoons, perforated plates, combustion boats.

### The Non-Ferrous Metal Market

The past month has been one of unusual activity in the non-ferrous metal markets. With the exception of tin, which stands in about the same position as a month ago, the metals command higher prices. A good volume of business has been transacted. Lead has experienced a decided rise, the demand being for ammunition purposes and export. Spelter has continued its unprecedented and spectacular rise, and the climax seems to have been reached.

**Copper.**—Electrolytic copper has risen steadily to 20 cents per pound, New York, due to the development of an active buying movement on the part of manufacturers of brass for ammunition purposes. Lake copper sold by the Calumet & Hecla company has maintained a price of 23 cents, but there is a tendency on the part of consumers to substitute electrolytic for Lake at these prices, and the differential is diminishing.

**Tin.**—A lull was experienced in this market during the latter part of May, but increased transactions early in June restored a firmer tone. The metal is quoted at about 40 cents, New York.

**Lead.**—An advance began late in May, due to large inquiry from ammunition makers, and the price was set at 4.30 cents, New York, by the A. S. & R. Co. Later the advances became a matter of daily occurrence and reached nearly 7 cents. A large business was transacted before the market began to decline.

**Spelter.**—June spelter reached the record price of 25 cents, St. Louis, on June 9, and about the same time the demand began to diminish. The galvanizing trade is practically out of the market at these prices, and other consumers have shown a disposition to withhold for the time being. The fluctuations in price have been rapid and wide, and an accurate quotation is difficult.

**Other Metals.**—Aluminium has been active and strong, and the price has risen to 27 to 29 cents, New York. Antimony continues strong, with a range in prices from 35 cents for ordinary brands to 48 cents for Cookson's. The latter is largely nominal. Quick-silver has again risen, small lots bringing \$100 per flask of 75 lb., and larger orders \$85. The price at San Francisco is somewhat lower, ranging from \$75 to \$85.

### Personal

Mr. George O. Bradley, consulting mechanical engineer for the Utah Copper Co., has been retained to design and supervise the construction of the 8000-ton Alaska Juneau mill. Mr. Bradley designed the new mill for the Alaska Gastineau company.

Mr. Sidney Cornell is now efficiency engineer of the Remington Arms & Ammunition Co. at Bridgeport, Conn.

Mr. Russell T. Cornell, engineer of mines, announces the removal of his office to 80 Maiden Lane, New York City. His new quarters adjoin those of Ricketts & Co., Inc., by whom he has been retained as associate mining and consulting engineer. His new association will not affect his status as an independent engineer.

Mr. F. M. De Beers, general manager of the Swenson Evaporator Company, of Chicago, was in New York in June and reported very lively activity in evaporator construction for various new chemical industries.

Mr. J. V. N. Dorr has returned to New York from Denver.

Mr. L. G. Eakins, former assistant manager of the Colorado department of the American Smelting & Refining Co., has been appointed general manager for Colorado, succeeding the late Franklin Guiterman. Mr. Eakins has also been appointed president of the Carbon Coal and Coke Co.

Prof. Albert J. Houle, of the department of mining and metallurgy, Michigan College of Mines, is spending part of the summer in Utah studying metallurgical processes.

Mr. Dorsey A. Lyon, of the Bureau of Mines, has returned to his station at Salt Lake City following a visit to the Joplin zinc and lead districts.

Mr. Ferdinand McCann is in charge of the erection of new milling plant at La Cotabambas Auraria mine, Peru.

Mr. Benjamin Magnus is returning to America and expects to be in New York by September, where his headquarters will be in care of H. M. Toch, 320 Fifth Avenue, New York City. Mr. Magnus went to Australia in 1907 to build the Electrolytic Refining and Smelting Company's Works at Port Kembla, N. S. W., for the refining of copper produced by Australian mines. In 1912 he became general manager of the Mount Morgan Gold Mining Co., Ltd., and designed the new smelter works and concentrator and reorganized the company's business generally. He also acted as consulting engineer to the Electrolytic Refining and Smelting Co., Ltd.

Mr. H. T. Matthew has been appointed Pacific Coast representative of the Society for Electrical Development. Mr. Matthew has with him the best wishes of many readers and friends of this journal of which he was the business manager for six years when it was still called Electrochemical & Metallurgical Industry.

Professor Arthur A. Noyes, of the Massachusetts Institute of Technology, is the recipient of the Willard Gibbs medal for 1915, awarded by the Chicago section of the American Chemical Society.

Mr. O. B. Perry, general manager for the Yukon Gold Co., has left New York on a trip of inspection of the company's properties in California and Alaska.

Mr. Charles H. Schmalz has been appointed manager of the Billings Foundry & Mfg. Co., of Billings, Mont. For the past six years Mr. Schmalz was master mechanic for the Anaconda Copper Mining Co., Boston, and Montana Reduction Department, Great Falls, Montana.

Mr. Arthur Putnam Scott, formerly with the Dominion Iron & Steel Company of Sydney, N. S., and with the General Electric Company, is now chief metallurgist of the Snyder Electric Furnace Company of Chicago. Mr. Scott contributed to this journal a most interesting article on "hard spots" (July and August, 1908, vol. VI, pages 281 and 323).

Mr. G. F. Streich is in charge of the zinc smelting plant at Bruce, Kansas, leased and operated by the Cherokee Zinc Co.

Mr. W. C. Tharp has been appointed district manager in charge of the Pittsburgh office of the Hoskins Mfg. Co. Mr. Tharp has been associated with the Republic Iron & Steel Company, the Scientific Materials Company, and the Metallurgical Testing Laboratory of Pittsburgh.

Mr. A. E. Wiggin has been appointed superintendent of concentration for the Anaconda Copper Mining Co., and will have charge of concentrating operations in Montana. Mr. Ralph Hayden has been appointed superintendent of the regrinding and flotation plants at the Washoe works, and will also have charge of the new slime plant on its completion. Mr. W. A. Estabrook retains the position of superintendent of the concentrator at Anaconda. Mr. C. R. Wraith has relieved Mr. E. S. Bardwell at the company's exhibit at the Exposition.

### Obituary

Thomas Dyson West, iron foundry expert, died in June as a result of the injuries received when run down by an automobile near his home in Cleveland, Ohio. Mr. West was widely known in this country and abroad for his untiring efforts for the foundry industry, while his organizing and developing of the American Anti-Accident Society and the Sane Fourth Movement show the broad field which he endeavored to cover. Thomas D. West was born in Manchester, England, on August 31, 1851, his mother being a niece of Michael Faraday. He was brought to the United States by his parents when six months of age. At twelve years he began to work in a foundry and remained true to the foundry industry ever since. Mainly self-educated, he was from 1887 to 1909 organizer, vice-president, and general manager of the Thomas D. West Foundry Co., now Valley Mould & Iron Company, Sharpsville, Pa. In 1907 he organized the West Steel Casting Company of Cleveland, Ohio, of which he was chairman of the board and managing director at the time of his death. By his research work and by his writings he gained wide recognition as a foundry metallurgist. He was the originator of the use of standardized drillings, adopted by the U. S. Bureau of Standards in 1905. In 1905-6 he was president of the American Foundrymen's Association. He also was a member of the American Society of Mechanical Engineers, the American Society for Testing Materials, the American Association for the Advancement of Science, and the Cleveland Engineering Society. He was a prolific author. Of his books, "American Foundry Practice," which has reached its eleventh edition, is probably best known. He is survived by his widow, Mrs. Clara West, and three children, Dr. Thomas J. West of Honolulu, Mr. Ralph H. West, president of the West Steel Casting Company of Cleveland, and Mrs. William E. Ward of Cleveland.

Alain de Pierrefeu, engineer in charge of the metallurgical and industrial division of tests of the Illinois Steel Company, South Chicago, was killed in May in France. Educated in France and in the Lawrence Scientific School he entered service in the mills of the steel company in the lowest position seven years ago. He worked up through the laboratory section until he had charge of testing all kinds of special steel and various treatments of structural steel. He was an officer of the Seventeenth Infantry and left for the war last October. Letters to Langdon Pearse state that he was wounded about two months ago and had been obliged to leave the trenches on account of eye strain. His wife, a daughter of William Tudor, of Boston, is in Red Cross work abroad but the four children are with the grandparents in Boston.

**Erratum.**—The communication by Mr. Carlton G. Lutts on rapid analysis of bearing metals and high-copper content alloys, published in the June issue, page 346, contains a misprint in the second column under copper (B), where  $\text{Na}_2\text{S}_2\text{O}_3$  (sodium thiosulphate) should read  $\text{Na}_2\text{SO}_3$  (sodium sulphite).



### Newspaper Chemistry

There was a man in our town  
And he was wondrous wise,  
He cracked petroleum odds and ends  
With vim and enterprise.

He first cracked off some gasoline  
And then some heavier bodies  
Until he made a full, long list  
Of Coal Oil Johnny's toddies.

And when he saw what he had done  
With all his might and main  
He curled them up, and into rings  
He twisted every chain.

'Twas then the newspapers began—  
And that's where chemistry  
Can work all sorts of miracles  
Most expeditiously.

The papers first took up benzol,  
And, quoting Edison,  
They made phenol by synthesis,  
And dyestuffs, every one:

Alizarine and indigo  
And all the coal-tar group  
For dyes and photochemistry  
They made in one fell swoop.

Then starting out with toluol  
They made explosive stuffs  
To smash the foes of Uncle Sam  
In detonating puffs.

They made a neo-gasoline  
For motor trucks and cars  
So cheap that poor old Standard Oil  
Was jolted full of jars.

And with this neo-gasoline  
They ploughed the fertile fields,  
And then, by using radium  
They multiplied the yields.

Of wheat, potatoes, millet, corn  
And rye and peas and beef;  
They banished want and poverty  
And hunger, past belief.

I wish I were a chemist of  
The journalistic kind!  
I'd take and go to work and make  
A contract, drawn and signed

To furnish everything there is  
And set the world agog;  
And do it just as easy as  
A-rollin' off a log.

—"E. H." in *The Percolator* of the New York  
Chemists' Club.

The spectroscopic analysis of steel has been investigated by the Bureau of Standards, at the request of the steel industry. It has been possible to show the presence of appreciable amounts of molybdenum, cobalt and vanadium in steels supposed to be free from these elements. No sample of iron has been found free from magnesium or copper. Silicon was not detected in electrolytic iron that had not been fused.

### National Exposition of Chemical Industries

The arrangements of the National Exposition of Chemical Industries, to be held in the New Grand Central Palace, New York City, during the week of Sept. 20 to 25, 1915, are progressing very favorably. Almost one-half of the available space of the main floor has already been reserved by prospective exhibitors.

An auditorium will be provided with arrangements for slide pictures and moving pictures for special lectures by invited prominent speakers. In the evening this auditorium is to be used for meetings of the different chemical societies. The date of the meeting of the New York Section of the American Electrochemical Society has already been fixed for Tuesday, Sept. 21. Other evenings are to be reserved for the New York Section, as well as for the Industrial Section of the American Chemical Society, and for the American Institute of Chemical Engineers and for the New York Section of the Society of Chemical Industry.

The Bureau of Foreign and Domestic Commerce of the Department of Commerce, Washington, D. C., has expressed its hearty sympathy with the Exposition and is expected to arrange a noteworthy instructive exhibit in conjunction with the Geological Survey, the Bureau of Mines, the Bureau of Soils, the Forest Service, and other government bureaus.

The Exposition is being organized by Messrs. Charles F. Roth and Adriaan Nagelvoort, with offices at the New Grand Central Palace, Forty-sixth Street and Lexington Avenue, New York (telephone 6990 Murray Hill), with the co-operation of the International Exposition Company.

### Digest of Electrochemical U. S. Patents

PRIOR TO 1903

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

#### Aqueous Bath, Anodes

226,616, April 20, 1880, Jacob Kleinhans, of New York, N. Y.

Relates to anodes for electroplating and describes shaping the anode with an oppositely bent hook at each end, so that a greater or less number of such anodes may be hooked together to increase or decrease the size of anode immersed in the electrolyte.

330,247, November 10, 1885, Henry Liepmann, of London, County of Middlesex, England.

Relates to anodes for electroplating and consists of a bundle of carbon rods, each having copper-plated ends, the assembled bundle being then copper-plated over the ends, or united by cast metal which enters the interstices between the rods. Instead of copper-plating, or cast metal caps, a plastic carbonaceous paste may be used to unite the rods, the paste then being carbonized, forming a solid composite carbon block. The compound electrodes thus made may be mounted between disks, forming a rotary drum for use in electrolytic apparatus.

450,105, April 7, 1891, Ernest Arthur LeSueur, of Ottawa, Canada, assignor of one-half to Charles N. Waite, of Newton, Massachusetts.

Relates to anodes for electrolytic cells, the anode consisting of a number of irregularly shaped pieces of gas-retort carbon, cut to an equal length, all united at one end by immersing in a shallow layer of molten lead, the lead on cooling gripping the several pieces of carbon and forming an anode having an extensive surface, and good electrical contact with each piece.

482,724, September 20, 1892, Thomas Craney, of Bay City, Michigan.

Relates to anodes for electrolytic cells, such as are used in the decomposition of sodium chlorid solutions. The anode consists of a nest of truncated cone-shaped tubular earthenware bodies, or the like, each having side projections by which they are supported upon and within each other, and leaving cylindrical spaces between each cone. The nest of cones is filled with lumps of conducting carbon, the cylindrical spaces also being filled with the same material and leaving the horizontal annular edge exposed to the electrolyte. Instead of separate cones, an earthenware tube with a perforated wall may be used. Instead of using lumps of carbon, a solid block of carbon may be used in the cones or tube, the spaces between the cones being filled with lumps of carbon which contact with the solid block. The cones may also be filled with a carbonizable mass of carbon and binder, and then baked to carbonize the binder.

508,091, November 7, 1893, Elisha Barton Cutten, of New York, N. Y.

Relates to contacts in anodes for batteries, and for electrolysis, and consists in cutting a tapered hole in the end of a rod or block of gas carbon, saturating the carbon surrounding the hole with paraffin, saturating a tapered carbon plug just fitting the hole, and having a projecting outer end, with paraffin, and then driving the plug tightly into the hole in the rod of carbon. A conducting wire is secured to the projecting end of the plug. It contains a reference to another application which is probably patent No. 510,899.

510,899, December 19, 1893, Elisha Barton Cutten, of New York, N. Y.

Relates to anodes for electrolytic cells, and refers to his copending application which became patent No. 508,091. The patent describes a method of testing the joints for resistance by passing a rather strong current through the electrode and measuring the fall of potential by a voltmeter. The joints are adjusted until all show the same fall of potential with the same current.

510,901, December 19, 1893, Elisha Barton Cutten, of New York, N. Y.

Relates to electrodes for voltaic cells and anodes for electrolytic cells, and refers to his copending application which became patent No. 508,091. The carbon electrode is secured to a glass cover by melting glass fragments or pouring molten glass around the joint between the electrode and cover, on the under side, or by melting the glass cover itself by a blow-pipe flame. The molten glass flows into the pores and cavities in the carbon, welding it to the cover, forming a gas-proof joint, and serving to suspend the carbon. Electrical connection is made with the electrode by a tapered carbon plug, as described in his earlier patent.

510,902, December 19, 1893, Elisha Barton Cutten, of New York, N. Y.

Relates to electrodes for voltaic cells and to anodes for electrolytic cells, and refers to his copending application which became patent No. 508,091. It describes securing the electrode to a stoneware cover by fusing glass fragments around the joint between the carbon and the underside of the cover, forming a gas-tight joint, and serving to suspend the electrode. Electrical contact is made with the electrode by means of a tapered carbon plug, as described in his earlier patent.

546,328, September 17, 1895, Carl Hoepfner, of Gies-sen, Germany.

Relates to an anode having a surface containing at least 10 per cent of silicon, which may consist of ferrosilicon or of pure silicon. The ferrosilicon may be formed by mixing iron and silicon powders with paraffin, the patent not stating how the alloying is effected. It states that the ferrosilicon may be deposited electrolytically. Or a solid electrode may be made in

any suitable shape by casting ferrosilicon. The patent further states that pure silicon may be deposited upon an iron or nickel anode.

## Book Reviews

**Welding.** Theory, Practice, Apparatus and Tests. By **Richard N. Hart**, B.S. Second edition, octavo, 210 pages, 127 illustrations; price, \$2.50 net. New York and London: McGraw-Hill Book Company.

The practical art is advancing so rapidly that revision was made necessary by the great advances made, especially in arc-welding and oxy-acetylene systems. The divisions of the subject are ordinary welding, electric welding, hot-flame welding (autogenous welding), thermit welding and miscellaneous methods. It is a very satisfactory presentation of a most interesting and useful art.

**Ferromangan als Desoxydationsmittel.** von W. Rodenhauser. 15 x 23 cm., 127 pages, 49 illustrations. Price 7 marks (retail price in New York \$2.35). Leipzig: Oskar Leiner.

Engineer Rodenhauser is well known to steel metallurgists for his work on the Roehling-Rodenhauser induction furnace. This timely book (dedicated to Mr. Roehling) is concerned principally with the latest improvement in manufacturing steel—the addition of molten ferromanganese. It describes the properties and function of ferromanganese, the various means for melting it, and the advantages resulting from adding it melted to the steel. The melting is described in detail as carried on in Rombach, Keller, Girod, Heroult, Nathusius and Roehling-Rodenhauser furnaces. We are sorry to see the Rennerfelt furnace omitted, for a good description of its usefulness for this very purpose was published by the Iron and Steel Institute last year. Notwithstanding this omission, it is a book which every steel maker ought to read.

**Principes et Applications de L'Electrochimie.** By O. Dony-Henault, H. Gall and Ph.-A. Guye. Large octavo, xxii + 686 pages, 183 illustrations; price 30 francs, in New York \$6.00. Paris and Liège. Librairie Polytechnique, Ch. Beranger.

A splendid volume, containing treatises on the fundamental laws of electrochemistry by O. Dony-Hénault, the synthesis of nitric acid by Ph.-A. Guye, and the other applications of electrochemistry by O. Dony-Hénault and H. Gall. And yet, such is the present great extent of applied electrochemistry that each of the subjects must be spoken of as "briefly considered."

*Mirabile dictu*, here is a French book with a good analytical table of contents in front and satisfactory indexes of authors and subject matter at the back. What further proof could be needed that it is the best book in its field in the French language?

**I Processi Termoelettrici della Siderurgia Moderna: Forni Elettrici.** By Ing. C. F. Bonini. 15 x 23 cm., 607 pages, 174 illustrations. Price \$12.50 lire. Milan: Ulrico Hoepli.

A beautifully printed and well-illustrated treatise on the electric furnaces used in the metallurgy of iron. Part I, in thirteen chapters (318 pages), deals with the principles of construction and operation of electric furnaces in general; it is well written. Part II, in five chapters (105 pages), treats of the direct production of steel from iron ore and the refining of steel; this part is not so thoroughly handled. Part III, in six chapters (170 pages), concerns the production of cast iron and ferro-alloys; it is quite satisfactory.

Any engineer reading Italian and interested in electro-metallurgy or electric furnaces will find it a useful book.